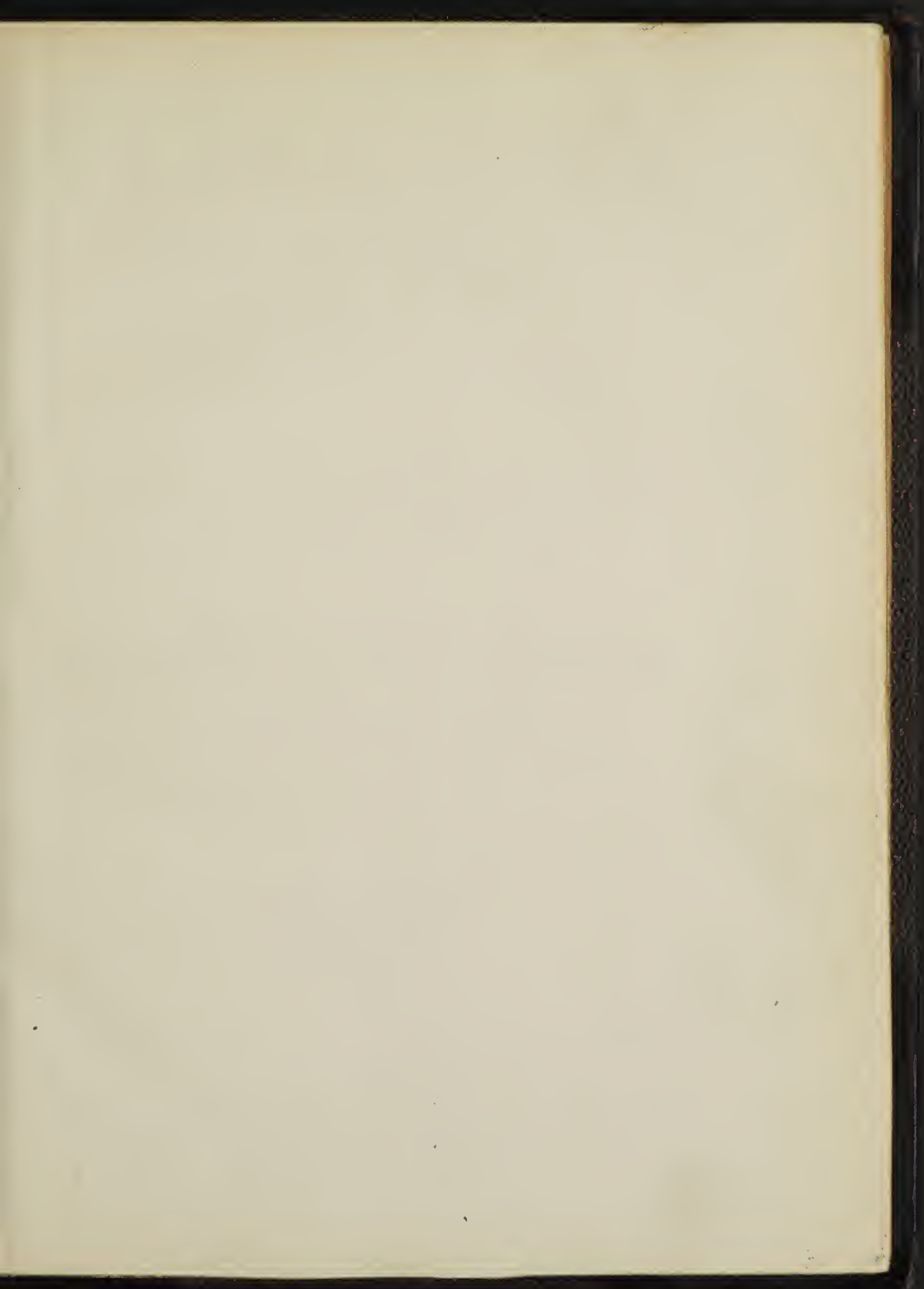
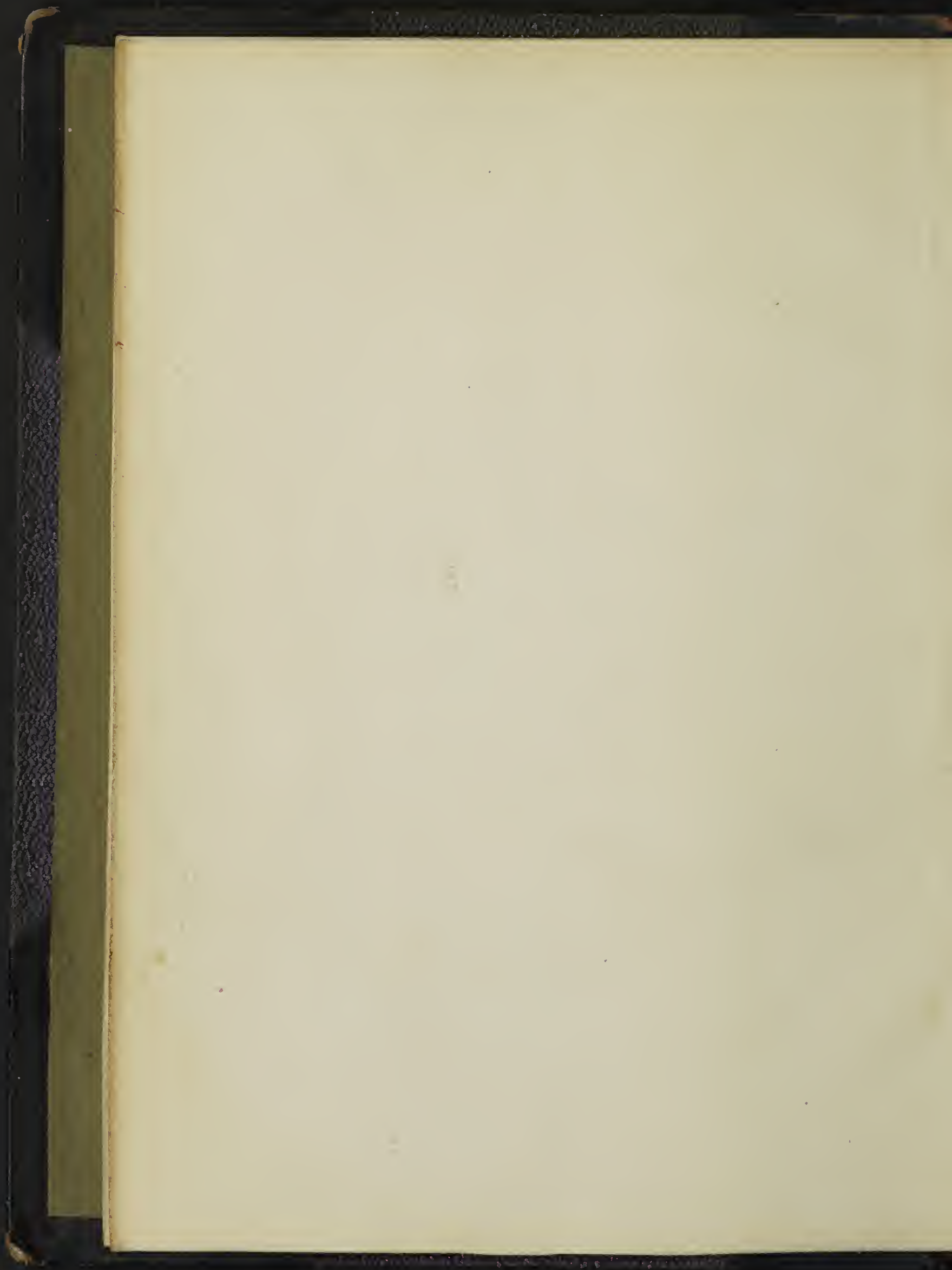


D. XVIII. 17413 / 8

7/c





NATURAL
HISTORY

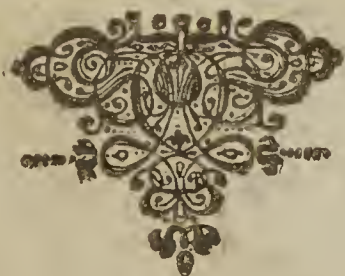
NUTRITION,
OF LIFE, and
VOLUNTARY MOTION.

Containing
All the *NEW DISCOVERIES*
of *ANATOMISTS*'s, and most probable
Opinions of *PHYSICIANS*,

Concerning the
OECONOMIE OF HUMAN NATURE;

Methodically delivered in
EXERCITATIONS PHYSICO-ANATOMICAL.

By *WALT. CHARLTON: M. D.*



LONDON,

Printed for *Henry Herringman*, and are to be sold at
his shop at the *Anchor* in the lower walk in the
new *Exchange*. 1659.

THE HISTORY

OF THE
CITY OF LONDON
FROM THE FOUNDATION
TO THE PRESENT TIME

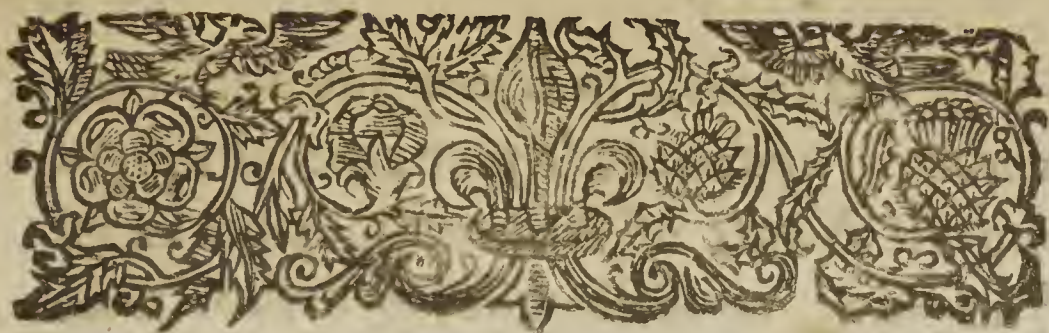
BY
JOHN STOW
Gentleman

PRINTED BY I. I. B. [illegible]

IN THE YEAR 1618



By the Author's Son, JOHN STOW, Esq.
of the Inner Temple, Esq.
1687



TO THE
RIGHT HONORABLE
THOMAS, VICOUNT
FAUCONBERGE.

MY LORD,

I *was the saying of a learned, wise, and great Man, of our Nation, that Books of Use ought to have no Patron, but Truth and Reason; And whether or no I have observed this Rule, in devoting this Book to your Lordship's Patronage, will not be much disputed by Any, who have the Hap-*

The Epistle Dedicatory.

piness and Honour to Know you well. For, whoever understands your general insight into all Kinds of Learning, your exact Judgment in distinguishing Truths from Falshoods, however subtilly concealed and plausibly delivered, and your strict Reasonings in all Arguments offered to your Consideration; doth need no other proofs to convince him, that, if You are not Truth and Reason it selfe Animated, yet (at least) you have them in you, in so eminent a degree, that it can be no Flattery to say, You are therein a Grand Exemplar to Others : nor will the most Scrupulous refuse to embrace, as Authentique and Current, whatever Position hath once received the stamp of your Assent and Approbation. So singular a Felicity it is, to render Nobility more illustrious with Learning ; to have long cultivated a fertil Mind, with select Precepts, and usefull Observations of Men and Manners ; and alwayes to make mature Deliberation the Harbinger to Belief, as well as to Action.

Besides, the Argument of this Discourse

The Epistle Dedicatory.

course, which now humbly seeks your L^{ps}.
Countenance, is much more proper and
fit for Your Cognizance, than vulgar
Eyes perhaps may judge, when they
first glance upon the Title of it. For (to
omit, that it leads to the most excellent of
all Human Knowledges; the Knowledge
of Ones self, which is the ground-work of
Civil Prudence) it explaineth the most
probable Oeconomy of Nature in per-
fect Animals; and especially the most per-
fect and noble of them, Man: A piece of
Science, certainly, so far from being Unne-
cessary to a States-man, that I dare affirme,
None can ever attain to any compe-
tent proficiency in the Mysteries of
State principles, or the Art of Govern-
ing Men, who is not in some measure
conversant in the Mysteries of Human
Nature, as well those which concern the
Constitution and Fabrique of the Body,
as those which belong to the Inclinations
and Passions of the Mind. And, the
Reason hereof is obvious and plain; since
the Maximes of sound Policy ought to be
deri-

The Epistle Dedicatory.

derived from the Lawes of Nature, at least by way of Analogie and Imitation : & the best way to understand, how to preserve Men in Societies, is to observe, How Nature at first produceth, and afterward conserveth them in their single Persons, or individual Beings. Certainly, My Lord, the highest pitch, to which Human Wisdom can aspire, is, to imitate the works of God in his Creatures: and the most perfect Model or Form of Government, is that, which comes neereſt to the Idea of the Divine Constitutions, either in the larger Volume of the Universe, or in the exact Abridgment of it, the Body of Man. This made Pythagoras call Man, the Measure of all things. This makes the greatest Politicians ſo frequently conſult the oraculous Aphoriſms of our perpetual Dictator, Hippocrates; and transferre His Rules of curing Diſeales of the Body, to the composing Diſorders, and rectifying Diſtempers in the State. This Menenius Agrippa found a happy truth ; when He, in a moment, appeaſed the ſeditious and mutinous

The Epistle Dedicatory.

tinous Commons of Rome, only by a speech, wherein He compared the several Members requisite in a well-ordered Commonwealth, to those in the Body of Man ; and shew'd the Offices of Those, to be as necessary as the Functions of These. And, this that incomparable Sophy, the Lord St. Alban, seems to have reflected upon, when He said, It was without president, that any Government had been disastrous in the hands of Learned Governours ; and doubted not to call those, Empirique States-men, who are ignorant in Natural Philosophy. I could, My Lord, expatiate in this noble and ample Theme, and permit my Pen to run into a Parallel betwixt the several Parts in a Body Politique, and those in the Body Natural ; and demonstrate the neer Affinity and Correspondence of them, in their respective Uses, Actions, and wayes of subministring to the Health and Conservation of the whole : but that I here speak to a Person, to whom such speculations are so familiar, that I should derogate

The Epistle Dedicatory.

gate from the *Vastnesse* of his Parts, to imagine it needfull for me onely to put Him in Mind of them, or (indeed) of any thing else suitable to that place of *Eminency*, and Condition of *Dignity*, to which his *Virtues* have advanced Him.

Now, My Lord, these my Exercitations being thus, in a Twofold Respect, capable of your Lordships Favour; their Ambition in seeking to acquire to themselves more of Value and Esteem, from the Knowing and Ingenious part of Mankind in our English World, by carrying your illustrious Name in their Front; is not only Excusable, but also Commendable, as being grounded on the Law of Decency, which forbade them to addresse to any other Sanctuary; and which evinceth, that this their applying themselves to your Lordship, was upon due Regard, not upon Facility.

And, for my Own part; that I have taken this way of Testifying the extraordinary Respect and Honour I bare to your Person and Virtues: this is to be imputed, partly

The Epistle Dedicatory.

*partly to the Humility of my Condition;
which permits me not to be so happy, as to
have any better Means, or Opportunity
of expressing my Devotion; and partly to
my Gratitude, for the many singular Fa-
vours Your Generosity long since con-
ferred upon me, which alwayes urgeth me,
in the best manner I am able, to acknowledg
my selfe,*

My most Honoured Lord,

Your Lordships

Most humble, and most
entirely devoted Servant,

Walt. Charleton.

The

Handwritten text in a cursive script, likely a letter or a page from a manuscript. The text is arranged in several lines, though the specific words are difficult to decipher due to the cursive style and fading.

Handwritten text, possibly a signature or a date, located in the lower middle section of the page.

Small handwritten text or mark at the bottom left of the page.

The Stationer to the Reader.

THat you might be acquainted with the Occasion of the Author's writing this discourse, his Design therein, and the Motives that induced Him to consent to the Publication of it ; I have obtained leave of him, to Print also this following Epistle of his to that Excellent Person, Dr. Ent, to whose peircing and impartial judgment, he thought fit to submit his own, as well concerning the Verity and weight of what his Papers contained, as concerning the fitnessse of their Constitution to endure the publique air. And this Favour I was the more importunate with him for ; both because it might evidence his Modesty, in distrusting his own Exactnesse : and because it might appear, it was not only his Inclination, that brought this Book into my hands, and so into yours. Besides, I was not so improvident of my own Advantage, as not to understand, how much of Reputation the Booke hath acquired to it self, by passing the Examination of a Man, whose Universal Learning, and admirable Perspicacity in things of Nature, have conspired to render him as competent a judge of such Treatises, as the World affords. This I say, not to assure you, that Dr. Ent found nothing in these Papers, from which He thought fit not to dissent; because, the subjects of Philosophers speculations and Enquiries, being usually very obscure in themselves, it is no rarity to meet with Diversity of Opinions among Them, as well as among the Vulgar : but, thus much I dare avouch, that He dissented but in very few points, and those only concerning such difficulties, that are not yet cleerly determined by Anatomical Observations ; and that neverthelſe, He pronounced the whole work to have been undertaken upon mature Consideration, and done with singular Care, Industry, and Circumspection. And I doubt not but you also will be of the same Opinion, when you have attentively read the booke ; in which confidence I commend it into your hands, being not a little glad of so good an opportunity to manifest my devoir toward the advance of Knowledge, and service of the Publique.

Hen. Herringman.

Clarissimo Atque Ornatissimo
Viro.

D. GEORGIO ENT,

M. D. &

Celeberrimi Medicorum Londinensium
Collegij, Socio dignissimo.



Nnus jam ferme elapsus est (Præ-
clarissime Vir,) ex quo è Magnati-
bus nostris Quidam (insignis qui-
dem Hippocraticæ familiæ Fauctor,
& cujus, in cæteris omnibus quæ ad
veram Sapientiam spectant, erudi-
tissimo Animo singularem res etiam
Physicas altius contemplandi avidi-
tatem, à juventute usque infuderat Ipsum Naturæ Numer.)
quotidiana, mihi que prorsus ineluctabili precum impor-
tunitate, à me efflagitabat; ut, sepositis aliquantisper, qui-
bus tunc temporis totus incumbebam, studijs, nupera Ana-
tomicorum Inventa, simul cum celebrioribus Medicorum
super iisdem Sententijs, maximè quæ Arti nostræ & lumi-
nis & augmenti plurimum attulisse hodie censentur, bre-
viter Sibi, atque ex ordine, enarrarem. Neque enim (ut aie-
bat) otii tantum à seerioribus Reip. negotijs suffragari po-
tuit, quantum satis esset perlegendis omnibus, quæ de re A-
natomicâ novi quid, supraque Vulgarem Genium sabli-
mis, in se continerent, Recentiorum Voluminibus.

Ipse

Ipse autem, quò illustris adeò Viri, mihiq̃ue verè Patroni, imperio, quantum in me esset, obsecundarem; ne tam laudabilem, quàm flagrabat heroïca Mens, in reformatæ Anatomies mysteria inquirendi sitim, diutiùs in expletam relinquerem: quam demandare placuit, provinciam in me libenter suscepi. Mox itaque ad Authorum eorum, quorum seu Industriæ, seu disquisitionum Felicitati, nuperas in Medicorum Scholâ Novitates debemus, iteratam lectionem seriò me accinxi; atque ex iisdem denuò quæcunque Mæcenatis mei expectationi satis facere posse judicabam, fidei calamo exscripsi: nec vadium datum ante deserui, quàm Ἀποσποσμάτα simul in unum (qualis de Oeconomyâ Animalium, juxta recentes in Anthropographiâ Hypotheses, ingenuè Philosophantem decere videretur) continuum Tractatulum consuissem; adjunctis hîc illic quibusdam Ratiociniis, quæ ad cæterorum sive elucidationem facerent, sive connexionem.

Cæterum, Chartulas haud citiùs perlegerat Nobilissimus Dñus quiri, ipsas, non Sibi modo, sed & aliis utiles fore, generosa quadam Humanitatis exsuperantiâ, existimans; ulterius adhuc sui in me arbitrii experimentum capere adnixus sit, adque operis Divulgationem ardentissimè me sollicitaverit. Recusavi sæpius; utpote non ignarus, quàm exigui essent pretii hæ Lucubratiōnes, apud perspicaciores Sophiæ cultores; quàmque nihili sit ista Laudis messis, quæ ex Rhapsodicâ Scriptione, utcunque fidei elaboratâque, acquiritur: & quò me ipsum melius tueri possem, varia in contrarium adduxi argumenta. Dixi nimirum, quæ scripseram, in privatum solummodò Ipsius oblectamentum collecta fuisse, stylique impolitioris stamine contexta; ideòque summè temerarium fore, si extra privatos cancellos in publicum divagari permitterentur: pleraque ex contentis, licet Ipsi forsân novitatis specie arriderent, aliis tamen, maximè è Doctiorum

è Doctiorum censu, jam obsolescere: me denique occurrentibus in operis serie aliquibus Difficultatibus, quas vel omnino intactas reliquissent, vel sensu planè diverso explicassent. Emunctiores) eà interdum usum Conjectandi libertate, cuius me deinceps, post secundas cogitationes, forsitan meritò pœniteret. Sed plane frustra fui: Is enim, concepti semel desiderii pertinax, contra excusationem omnem aures occluserat. Quid agerem igitur? Hinc Viri Dignitas, & Amicitiae Sacra premebant; illinc Tenuitatis meae conscientia: Contra hanc peccare, temeritatis esset, atque insolentiae; nefas autem illa violare. Hòc Dilemmate obsessus, diu anceps sum animi, donec tandem ea conditione inter nos conventum est, ut cordatum aliquem ex Æsculapii Mystis, in rei decisionem, ilicò appellaremus. Acceptà itaque semel utrinque æquissimâ isthac lege; pronum erat, Quem è Nostratium Doctissimis in Arbitrum seligeremus.

TE enim, Vir Excellentissime, quem esse cum omnes meritò agnoscunt, in quo Eruditioni summæ (sine fūco dicam) summus accessit Morum candor, in ingens Medicinæ decus, Nominisque Tui immortalitatem; Quis aut Cordatior, aut Æquior poterat nominari in iudicem? Tuum itaque penes arbitrium jam est, ut vel securis Musæoli mei tenebris, vel petulantis, inque Eruditorum scripta, supra quàm decet, severioris Vulgi Censuræ, adjudicetur Hicce, talis qualis est, de Humani Corporis Oeconomiae, Discursus: quem in eum finem ad E. T. nunc misi, vacivis horis (saltem nisi molestum nimis fuerit) evolvendum; non opinionem, sed Oraculum habiturus, quicquid super eodem è Delphico tripode responderis. Spero autem interim, antiquam tuam, & toties feliciter à me expertam, in Tui Cultores Humanitatem, mihi excusationi suffecturam, quòd sublimiores Tuas, atque in Artis nostræ (quam Dijs ipsismet adeò cognatam meritò agnoverunt Veteres) Compendium

dium usque defixas, Contemplationes, nugis meis tam diu
interpellare ausus sim: Teque etiam, utut in hac re sim
importunus, facile tamen posse exorari, ut amare pergas

Virtutibus Tuis addictissimum

Londini, 12. Junij
M. DC. LVIII.

Gualtrum Charletonum.

Postscriptum.

Est & aliud adhuc, quod ab. E. V. summo perè rogare
velim; nimirum, ut, sicubi à verò aberraverò, in viam
reducere dignetur; nec Censoriâ, ubicunque videbitur,
virgulâ abstineat. Mihi siquidem, exilitatis meæ semper
conscio, volupe admodum est, à Tali Viro corrigi, doceri que,

— Unum Tritonia Pallas
Quem docuit, multâque insignem reddidit Arte.

Galen.



OF NUTRITION.

Exercitation the First.

Of Nutrition.

He *Platonist*, though He holds the Deity, and the world to be co-eternal, doth yet allow the World to have been created by God : and to solve the seeming contradiction, saith, that *Priority* was not [κατὰ χρόνον] in respect of time, but [κατὰ φύσιν] in respect of Nature ; as the Sun and light are coævous, though the one be the Cause, the other the Effect. This, certainly, might be more justly said of the *Generative & Nutritive* Faculties (if at least, they be not one and the same) ; by one of which an Animal is *produced*, and by the other *conserved*. For, though the *Formative* Virtue may seem to precede in its operation ; yet are the *Stamina*, or rudiments of the Embryo scarce delineated, or adumbrated, when the *Nutritive* begins to augment and perfect them : So as that it may rather be said to go hand in hand with the *Plastick's* faculty, than to follow after it ; and what priority there seems to be in their o-

B

perations,

Article

I.

Nutrition and Generation, one and the same Act of the soul or Formative virtue.

perations is rather in respect of Nature, than of time. To forme, and nourish, are not only acts of one and the same soul; but so alike, that it is no easie matter to distinguish betwixt them. For, *Generation* and *Accretion* are not performed without *Nutrition*; nor *Nutrition*, or *Augmentation*, without *Generation*. To nourish, is to substitute such and so much of matter, as was decay'd in the parts, namely flesh, nerves, veins, arteries, &c. And what is that in reality, but to generate flesh, nerves, veins, arteries, &c? In like manner, *Accretion* is not effected without *Generation*; for all natural bodies, upon the accession of new parts are augmented, and those new parts are such of which these bodies were first composed: and this is done, according to all the dimensions; so that, to speak properly, the parts of an Animal are encreased, distinguished, and organized all at once. Farther, this is necessary both in respect of the *Efficient* cause, and of the *Matter*. The *Former*, because *idem esse principium efficiens, nutriendum, & conservans in singulis animalibus, necesse est; nisi aliam formam in puero, aliam in adolescente, et in sene aliam constituamus*. The *Latter*, because all Animals (such as are produced *per Epigenesin*, of which is our discourse; not of such Insects, as are produced *per Metamorphosin*) are corporated of one part of the matter prepared by the Formative Spirit, and nourished and augmented by the rest. For, Nature doth nourish and amplify all parts of an Animal with the same matter, or humour

(not

As well in respect of the Matter, as of the Efficient.

(not with a diverse) out of which she constituted or framed them at the first. Because, whatsoever is superadded to the parts, during their growth, ought to be of the same substance, with what was præexistent, and so must consist *ex congenera materia*: their Renovation as well as first Corporation being effected by *Epigenesis*, Aggeneration, or superstruction. So that we may well conclude, that Nutrition is nothing else but *continual Generation*: and as necessary to the Conservation of every individual nature, as Generation it self is to the conservation of the Universe.

To make this Necessity the more evident, we are to consider; (1) That forasmuch as an Animal cannot performe all the functions, of which its nature is capable, whilst it remains in the minute parts, and rude beginnings, in which it is first formed; therefore, there must succeed a Nutrition, that may dilate and amplify those slender *stamina*, by interweaving and assimilating so many other congenerous parts, as serve to advance and augment the Animal to a convenient magnitude: (2) That since the chief principle of life in every Animal, is a certain indigenary Heat (analogous to pure flame, such as the most rectified Spirit of Wine yeelds, upon accension) which by continuall motion and activity agitating the minute and exsoluble particles of the body, doth dissolve, and consume, or disperse them; of necessity, the whole Fabrick would soon be destroy'd, unlesse there were a continuall re-

2.

The necessity
of Nutrition,
two-fold, viz.
Augmentation
& *Conservation*.

novation or reparation of those decayes ; by a substitution and assimilation of equivalent particles, in the room of those dispersed and absorbed. So that, we see, the Necessity of Nutrition is *Two-fold*; one in respect of *Augmentation*, the other in respect of *Conservation*.

As to the continuall *Decay*, or *Depredation* of the substance of our bodies, wherein the latter necessity of Nutrition doth consist ; that we may the better understand the manner how it is effected , we are to enquire into the Causes thereof, *viz.* the Agent or Depredator, and the Matter or substance depredated.

3.
The Efficient
cause of the
consumption
of the parts, is
the *Vital Flame*

The *Agent* or *Efficient Cause*, with all Philosophers, we hold to be the *Naturall Heat*, or *Vital Flame*, at first kindled , by the vegetative soul, or Plastick spirit, in the blood, constantly burning in the Heart, as in its fountain, or primary *Focus* , and thence by diffusion of it selfe through the arteries, warming, cherishing, and enlivening all parts of the body. This *Lar familiaris* is called ἔμφυτον πῦρ, *ingenitus ignis*, by *Hippocrates* ; ἡ ἐν τῇ καρδίᾳ τῆς ψυχῆς ἐμπύρωσις, *Accensio animæ in corde*, the Kindling of the soul in the heart, by *Aristotle* ; and generally known by the name of *Calidum innatum* , the innate Heat. The principle of life, therefore, being a certain Fire , certain it is that the same cannot subsist or endure one moment of time, unless it be perpetually maintained or fed with some convenient ὑπέκκαυμα, *succendiculum* , or Fewell ; which is thereby indefinitely consumed : for, all Fire whatever (that Elementary Fire,

Fire, which the *Aristotelians* conceive to be so pure, as to need no *pabulum* or aliment, being a meer Chimera) doth conserve it selfe onely by the destruction of the matter, in which it is generated. So that, indeed, we have one and the same Cause both of our Life, and of our Death; or (to speak more properly) our Life is nothing but a continuall Death, and we live because we dye. For, so long we live, as this Vestall-Fire is kept glowing and shining in the sacrary of our heart: and when the same is put out, either by suffocation; or want of sustenance, life is instantly extinguished. And perhaps, it was to this *Euripides* alluded, when he said; *Quis novit autem, an vivere hoc sit emori:*

An emori, hoc sit quod vocamus vivere?

The Matter or substance consumed, we conceive to be the *Fluid* parts of the body, especially the Blood and spirits, which having in them something of the nature of oyle or sulphur, are the principal *succendiculum*, or Fewell of the vital Flame: and not the substance of the *solid* parts, at least not in that large quantity vulgarly supposed. For, experience teacheth, that sundry Animals, as Bears, Dormice, Swallows, &c. do sleep all the winter long, without receiving any supply of aliment: and yet have all their solid parts of their bodies, as large and firme, when they awake again in the spring, as when they first betook themselves to their dens or dormitories; nay, if we may credit Naturall Historians, they grow fat in this time of their long abstinence. Which doubt-

lesse

4.

The Matter thereby consumed, not the substance of the solid parts, but the *Fluid*, and chiefly the Blood and Spirits.

6
 lesse is to be ascribed to this, that the flame in their heart, all that time, being but gently moved, and burning quietly, doth consume very little of their spirits and blood. In like manner, we have examples of *Leucophlegmatique* virgins, who upon a decay of Appetite, have endured long abstinence from all sorts of aliment: and yet have not been emaciated in any proportion to their so diuturn fasting. So that it is more than probable, that there is not so rapid and profuse an exhaustion of the substance of the solid parts, by the activity of the vital Heat, as Physicians have vulgarly imagined. In many diseases, we confesse, the habit of the body is much extenuated; but that is only a subsidence or flaccidity of the Muscular flesh, caused by the defect of spirits and blood, by which the same was formerly distended and plumped up; not by any deperdition of the substance of the solid parts.

5.
 The Manner
 how they are
 consumed, is
 by continual
 Dispersion.

Lastly, as for the *Manner* how the blood and spirits (and, if you please to have it so, also the less fixed and more easily exsoluble particles of the solid parts) are absorbed by the vital Heat; it may be familiarly explicated by the example of the oyle consumed by the flame of a Lamp. Flame (as reason defineth it) is a substance luminous and heating, consisting in a perpetuall *Fieri*, i. e, an indefinient accension of the particles of its pabulum, or combustible matter, and perishing as fast as it is generated: so that fire is made fire, and again ceaseth to be fire, in every, the shortest moment of time; and

and when there remain no more particles in the combustible matter, wherein it may generate it selfe anew, it instantly perisheth. Continuall *Dispersion*, therefore, being the proper effect of Fire; the matter or fuel, whereon it subsisteth, cannot but be in perpetuall flux or decay. In like manner (that we may accommodate this to our present purpose) the *Lamp of life* consisting in a continuall accension of vital spirits in the blood, as that passeth through the heart; those vital spirits, transmitted by the arteries to the habit of the body, no sooner arrive there, but as they warme and vivifie the parts, so do they immediatly fly away, and are dispersed into the air, carrying with them many aqueous parts, and (perhaps) some sulphureous exhalations. Moreover, there being in all parts of the body certain sweet and balsamicall, or conserving spirits, as it were affixed unto and concorporated with them; the vital spirits meeting with and acting upon them, do by little and little render them volatile, and at length wholly disperse them: whereupon the minute particles, in which they did reside, become mortified, & as excrements of the body, are ejected together with the exhalations of the blood. And this is (as we conceive) the reason and manner of the depredation made upon the parts, by the vital heat.

If your Curiosity extend yet further, and you would enquire into the *Quantity* of Aliment daily devoured by this *Biolychnium*, or Lamp of life; the acute *Sanctorius* will tell you, that,

6.

And in what
Quality.

that, according to his static observations, men commonly avoid as much by insensible perspiration, in one day, as by stool, in fifteen. But so great is the variety among men, in respect of temperament, diet, age, exercise, the season of the year, and other circumstances; as that no definite compute can be made of this dispenſe. And yet we may be certain, that the proportion of blood and spirits daily exhausted by the flame burning within us, is very great: and that the most part of the matter of occult transpirations, is the vital spirits, which are continually generated, and continually dispersed.

From the consideration of the Causes and Reason of the Deperdition of substance in Animals, we may opportunely progresse to an enquiry into the Causes and Manner of the *Renovation*, or Restauration of it, by Nutrition.

7.
The Efficient
Principle of
the Renovation
of the parts,
what.

The *Efficient* principle (or ἀρχὴ κινήσεως καὶ ἀναγεννήσεως, as *Aristotle* calls it) certainly, is the very same with the Generant, or Formative; because, as we said afore, Generation cannot be without Augmentation, and Augmentation is Nutrition. Not that we are of their judgment, who hold that Life and Nutrition are different, not *in re*, but onely *in ratione*; for, the Embryo is nourished, before the *Empsychoſis*: but that we conceive, that Life doth consist in a continuall accension of vital spirits out of the blood, which is the pabulum of the Lamp of life; and that Nutrition doth consist in the restauration of what is consumed, by an Appoſition

fition and Assimilation of consimilar or congenerous matter.

The *Material*, or Constitutive principle, we take to be a certain sweet, mild and balsamical Liquor, analogous to the white of an egge, out of which the chicken is formed. For since all Animals are nourished with the same, out of which they were at first fabricated, according to that common Axiom, *iisdem nutrimur, ex quibus constamus*; and that of Aristotle, *eadem materia est, ex qua augetur animal, & ex qua constituitur primum*; and since they have their origine *ex Colliquamento*: we may well conclude, that the *Succus Nutritius* is in all qualities respondent to the Colliquamentum of the white of an Egge. Nor are they in the right, who thinke, that the parts of the body being diverse, those of the Aliment ought also to be equally diverse. As if Nutrition were nothing else but a selection and attraction of fit aliment; and that there were not required in every part a concoction, assimilation, apposition, and transmutation. For, the Aliment of all parts is common, and similiary, such as the white of an egge; not heterogeneous and composed of diverse parts: and it is the work of the Vegetative soul, as to forme all parts out of one and the same homogeneous matter at first, so afterward to augment and repair them out of the like, by transforming that into the substance of each part, which is potentially all parts, and actually none. As from the same rain all sorts of plants receive
C their

8.

And what the
Material.

their increment ; because the water, which was potentially life to them all, is now made actually life to each, being transmuted into the substance of each. Whereunto the *Philosopher* had respect, when, opposing the opinion of *Anaxagoras*,

De gen. Animal.
l. 2. c. 4.

Principium rerum qui dixit Homæomesiam,
He saith ; *Distinctio partium non, ut quidam opinantur, propterea fit, quia simile suapte natura ad simile fertur : nam præter alias multas, quas ratio ista habet difficultates, accidet, ut quævis pars similis seorsim creetur. Verbi gratia, ossa per se, & nervi, & carnes ; si quis eam causum approbet, &c.*

9.
And the Manner how they are renorated.

Lastly, as to the *Manner* how the parts are refected, or instaured ; it is most probable the same is effected by *apposition*, *agglutination*, and *assimilation* or *transmutation* ; all which must in order succeed each other, before the act of Nutrition can be compleat. For, the *succus nutritius*, being first prepared in the stomach and other organs thereunto inservient, must be brought and apposed to all the parts, that are to be nourished ; then from contiguity by apposition it must be advanced to continuity, by agglutination ; and lastly made of the same substance with them, by assimilation or transmutation, which is the perfection or ultimate term of Nutrition.

10.
Consecutary,
of the twofold
Expence of
the Chyle.

From what hath been said, it easily appears, that the expence of the Aliment (at least of the Chyle extracted from it) is *Twofold* ; one part thereof, being converted into the *succus nutritius*,

nutritius, for the instauration of parts : the other being converted into *Blood*, both for the fuel of the vitall flame, and for the confection of Spirits. That we may, therefore, the better understand the proceſſe of Nature in both theſe Operations; it is fit, we enquire into the method of *Chylification* firſt, and afterward into that of *Sanguification* : that we may comprehend the whole hiſtory of Nutrition from the beginning to the end.

OF CHYLIFICATION.

Exercitation the Second.

Of Chylification.

WHen we eat, whatſoever of ſolid Aliment is detruded into the Ventricle or ſtomach (for Deglutition is by way of detruſion) doth for a while obſerve the ſame order, in which it was ſwalloved down; vvhat vv as firſt taken, lying undermoſt, and vvhat laſt, uppermoſt : unleſſe it chance, through intemperance, that an exceſſive quantity of drink ſo diſtend the ſtomach, as that the meat be ſet afloat ; and then that order is changed into confuſion.

Article

I.

The Order of
the Meat in
the ſtomach.

When our hunger is ſatiſfied, and repaſt finiſhed, the ſtomach doth dilate it ſelf more or leſs, according to the proportion of meat and drink received, ſo as to imbrace the ſame

2.

The Poſture of
the ſtomach,
in Concoction.

closely and strictly on all sides; and then shut both its upper and lower orifice; the upper, that vapours may not ascend to the brain, and that the concoction may be the more perfect; the lower, lest any of the meat should descend into the guts, before it be converted into perfect chyle. Yet the lower seems not so strongly contracted, as the upper; because it hath been observed, that upon even a gentle compression of the body of the stomach, it easily yeelds to the pressure of the yet half-concocted meat, and permits it to pass into the guts. And sometimes the stomach is so weakened, by surfeits and frequent distension, as that neither of its orifices is drawn together so closely, as it ought to be; and in such case the Concoction is alwayes imperfect.

3.
The Dissolution
of the Meat,
by an Acid hu-
mor found in
the stomach.

The meat thus received into, and embraced by the stomach, is by and by moistened and diluted, partly by the drink, partly by a certain Acid humor contained in the stomach. Which being endowd with an incisive, penetrating, and dissolving faculty, doth as it were cut, and dissolve the solid meat into very small pieces, and (like an excellent menstruum) extract all the laudable and alimentary parts of it, *ad modum Tincturae*. But whether this Acid juice be ingenite in the stomach it selfe, or sent thither either from the Spleen (as hath been vulgarly believed) or from the celiacal arteries (as is most probable) we shall hereafter professedly enquire. In the mean while, certain it is, that this Acid liquor (or spirit, as some

some have named it) is so necessary to the stomach, as that it cannot happily performe its Office of Chylification vvithout it. For (to omit how much the same conduceth to excitement of Appetite) vvhen it is vvanting, the concoction is rendred so imperfect, as that the meat is avoided vvhole, as it vvvas svvallovved dovvn ; vvhicH Hippocrates seems to intimate, in the 1 Aphor. 3. sect. vvhere he saith, *In longis intestinorum levitatibus, si tactus acidus fiat, qui prius non erat, signum bonum est.* Certain it is also, that this Acidity, as it is not excited but by a moderate heat, so it is discussed and destroyed by an excessive. Which is the reason, vvhy the appetite is vvweak and languid in phlegmaticke constitutions, and cold distempers of the stomach ; and in Fevers, and hot distempers, vvholly taken avvay. Like as bread is vvry hardly leavened, in a cold place, and in an Oven not at all. But, we return from our digression.

The mixture of the solid and liquid parts of the aliment, being by this time advanced *usque ad minima*, so as the vvhole appears to be, one and the same fluid substance ; in the next place succeeds a *Fermentation*, not unlike the motion arising in vvine, vvwhile it defæcates it self. Vvhich *Fermentation* vve understand to be a certain Heat and agitation of all parts of the liquor, arising from a contest or strife betvvixt the Spirits and crasser parts, vvwhile the Spirits endeavour to expand themselves, and flye avvay, and the gross parts oppose

4.
Which causeth a certain
Fermentation
of the Chyle
therein.

pose and hinder that their endeavour. Now this is that motion, which being equivalent to long Elixation, doth so fully impregnate the potent part of the Aliment, with the spirits and virtues of the solid, as that it puts on the form of a whitish juice, in colour and consistence not much unlike the Cream of barley, generally called the *Chyle*, as the function or action of the stomach, by which it is so consecreted, is called *Chylification*.

5.
All parts of the Aliment, not Chylified at once, but successively: and the first Chylified, first discharged into the Guts.

But, here we are to advertise, that all the meat doth not receive this commutation equally soon; it having been observed in dissections, that some parts have been perfectly converted into chyle, and that chyle detrudd into the intestines and milky-veins; while the rest have remained wholly crude. Nor is it reasonable, that the whole mass of Chyle should be detained in the stomach; or that what is already concocted, should there stay and expect the perfection of what is not concocted: but that as fast as the chyle is made, so fast should it be discharged out of the stomach.

6.
The Time required to perfect Chylification, various, according to divers respects.

We are to advertise also, that as to the *Time* wherein the work of Chylification is wholly consummated, there is no small variety; as well in respect of mens individuall temperaments, as of quantity and quality of meats they eat, and also of the time of their meals, with other circumstances. For, in some men the digestion is compleated in 3, 4. or 5. hours space; while in others it extends to 8. 10. nay

13. which certainly is to be ascribed chiefly to the abundance of heat and Acidity in the stomachs of Those, and to the decay of them in These. Again, by how much the greater *quantity* of meat is devoured, by so much the slower is it digested. The same likewise may be said of the *quality* thereof; because the grosser, tougher and harder the aliment is, by so much the more difficulty is it comminished, cutt, dissolved, and fermented; and consequently the longer before it be concocted. Moreover, concoction is performed in the *day* much sooner, than in the night; notwithstanding the vulgar opinion, of the recession of the naturall heat towards the stomach, in sleep, for the promotion of Chylification: because in the day, by reason of motion and exercise, the Circulation is more free and swift, and so the distribution of the Chyle more expedite. Lastly, *Mastication* of the meat in the mouth is so necessarily præcedaneous to concoction; as that by how much the smaller the morsels are, and the better chewed, by so much the sooner are they digested. Nay, among the parts of the same meat, there is no lesse variety; so that some parts of bread and flesh commonly remain unaltered, a good while after others more tender and exsoluble are transformed into perfect chyle, and protruded into the gutts. So that no certain time can be assigned to Concoction in all men. But Nature it self hath given us a signe, by which every single person may know, when this chylification is finished in his stomach;

mack ; and that is a sense of emptinesse , and appetite to a supply or recruit of Aliment.

THE JOURNEY OF THE CHYLE

Exercitation the Third.

Article

I.
The traducti-
on of the
Chyle, from
the stomach
and intestines,
into the com-
mon Receptacle,
through the
vena Lactea.

THe Chyle, being, according to the manner declared, perfectly concocted ; is by degrees (the stomach gently and gradually contracting it self) expressed or detruded into the Guts ; and not attracted by them, as hath been commonly taught. The Guts being filled with this liquor, and by a certain peristaltique motion, or undulation, like that of worms creeping, contracting themselves successively from the first to the last ; transmit the same downward. And as it passeth through them , there is a separation made of the profitable or alimentary part, from the unprofitable or excrementitious : the latter to be excluded by stool ; the former to be protruded into the *Vena Lactea*, or milky veins. Which opening themselves by small orifices or inlets, in infinite number, into the coats of the intestines ; and running in continued channells from thence into the Mesentery : carry the Chyle into a certain common Receptacle or Gulph (called *Receptaculum Pecqueti*, from the inventor) consisting of a membranous substance , situate at the root of the mesentery , upon the *vertebræ lumborum*,

lumborum, and filling the space betwixt the Muscles *Psoæ*. From this common Receptacle there are derived other *ductus chyliferi*, which running upwards, neer the spine of the back, through the Thorax, and propagated quite home to the subclavian branches of the *vena Cava*, neer the external jugular veins, exonerate themselves into them; so as the Chyle being there commixed with the blood, is by the ascendent trunk of the *vena Cava*, soon imported, together with its new associate, the blood, into the right ventricle of the heart. And this, according to the late invention of *Perquet*, and anatomical experiments of the most accurate Dissectors since, is the true Traduction of the Chyle from the ventricle to the heart: at least of so much of it, as is to be converted into blood, for the fewell of the vital Flame, and confection of vital spirits.

That we may, with the more exactness and certainty, trace the footsteps of the Chyle in all its progress through these various and obscure Meanders; we are to observe, from Anatomical Demonstrations, two things concerning the Chyliferous Conduits. *First*, that there are (besides the Common Receptacle, and channells from thence ascending to the chest and subclavian veins) two kinds or sorts of the *venæ Lactææ*; one arising in slender capillary roots from the Intestines themselves, and thence delated through the Mesentery to some glandule or other, situate either in the Mesentery it self, or not far from it in some o-

2.
Of which there are two kinds, one arising from the Intestines; the other from the Glandules, in the Abdomen, into which the former sort exonerate themselves.

D

ther

ther part of the Abdomen, and there disseminated into capillary furcles: the other taking its origine out of that very Glandule, into which the former sort exonerate themselves. *Secondly*, that the Glandules in the Abdomen are not seated in the same places in all men; but are variously posited, here in some there in others, according as Nature (sometimes affecting variety in the same species, where conveniency admits thereof) pleaseth to fix them; and this without incommmodity to the body; and that from the incertainty of the position of these Glandules, the Distribution of the *venæ Lactææ* comes to be also various and incertain. For, Anatomy sensibly attesteth, that all the small furcles of the *venæ Lactææ* of the former sort (arising from the intestines) do constantly tend to some one Glandule in the lower belly; and are distributed into the same, before they arrive at the Common Receptacle, or disembogue themselves into any vein; yea (as was newly said) that they produce another race of Capillary branches in the Glandules, in which themselves were terminated; and that many of those small rivulets concurring and uniting, make one greater channell, before they lose themselves either in the Common ocean, or any branch of the *vena Cava*. Now, from the foresaid various position of the Glandules, it comes to pass, that the Distribution of the *venæ Lactææ* into their substance, and their new propagation out of them again, are so uncertain, as that it hath given occasion to some
Anatomist

Anatomists to suspect, that the *venæ Lactææ* are disseminated into very many parts of the body; when, indeed, they only come neer those parts, and then passe by them, without effusing any part of the Chyle into them.

Now, from these observations, it is very-probable, that all the *venæ Lactææ* (before the Chyle loseth its milky colour) do exonerate themselves either into the *vena Cava*, or some branches of it. And as for the *Lactææ Thoracicæ*, our sense demonstrates, that they empty themselves into the subclavian or Axillary veins (branches of the *Vena Cava*); so that none disgorgeing theirfraught or chyle into anybranch of the *vena Portæ*; it is most manifest, that no part of the Chyle is imported into the Liver (as was long believed and taught), there to be converted into blood; and consequently that the office of the Liver is not Sanguification.

3.
But none of either kind tend to the Liver.

Whether any of the *venæ Lactææ* are distributed into the *Paps*, and *womb*; in women; though highly probable, is yet in dispute: no Anatomist having hitherto been so happy in his searches, as to discover by what secret wayes or passages they tend to either. We say, highly probable; for, according to that judicious saying of *Hippocrates*, *Licet visum oculorum effugiant, ea tamen mentis acie comprehendantur*; though they have thus long concealed themselves from the eye of the body, yet are they obvious to the eye of the Mind: and the acuteness of our Reason may herein supply the dullness of our sense. Now, to evince the proba-

4.
That the Milk in the Papps is not made of Blood, but of meer Chyle brought thither by some peculiar vessels; because

bility of this Opinion, let us consider the sundry and weighty Arguments, that seem to assure, that *the Milk in the paps is not made of blood; but mere Chyle brought into them by some peculiar vessells.* Which though a seeming Parergy, is yet fully pertinent in this place.

5.
- There are no convenient conduits, by which Blood can be brought into the paps, in sufficient quantity.

Exam. obser-
vat. Fallop.
pag. 89.

First, there are *no convenient wayes or conduits*, by which Blood may be, in a due quantity, imported into the Paps, there to be whitened into Milk. For (1) the *Arteriæ Thoracicæ* can adferre but a small tribute of blood into the treasury of the Paps; and what they bring in, is soon exhausted and carried off again by the veins; according to the apodictical doctrine of the Circulation of the blood. But, did the blood remain in them; yet would it hold no reasonable proportion to the large quantity of milk usually effused in a day (which in healthy Nurses commonly amounts to two pints). Because the Arteries disseminated into the Paps, are exceeding small, as our eyes witness, and Vesalius, long since well observed, where He saith, *Exiguæ aut ferè nullæ arteriæ adeunt mammas, quod in mammarum cancro affectarum ablatione constat, ubi paucae aut ferè nullæ arteriæ sanguinem fundunt, cum tamen venarum magna copia sit.* (2) The *Arteriæ Hypogastricæ* cannot be thought to convey blood into the Paps; because they are terminated in a part far distant from their confines, and empty themselves where their streams are soon swallowed up and returned into the vena Cava by the Hypogastrick veins. (3) The same may be said of

of the Epigastrick arteries and veins. So that in respect of wayes importing blood into the Paps, it appears altogether unlikely, that that should be the matter of Milk.

Secondly, *Blood is not a fit, nay not a possible matter for the generation of Milk.* For (1) if blood should be imported into the paps, in sufficient quantity, and there extravasated; certainly it would be converted rather into pus, than into milk, as is frequently observed in Inflammations and Apostems of the Paps. (2) To what end should nature convert blood into milk, when that milk is to be soon converted again into blood, in the infant sucking it? (3) How is it possible, that the Chyle, which loseth its whiteness and other qualities, when it is transformed into blood; should resume them again, as soon as it becomes milk; *a privatione ad habitum*, is repugnant to Nature? (4) Meat and drink cannot be suddainly changed into blood, and that blood changed into milk; but experience teacheth, that the paps of nurses are filled soon after their repasts, and many women feel their milk flow swiftly into their breasts, almost as soon as they have drunk. (5) Women that are somewhat fat, have greater plenty of milk, than such as are lean: but, if blood were the matter of milk, the lean would afford more milk, than the fat; because the lean have larger arteries and veins, and so more store of blood. (6) If blood were the matter of milk, then would the bodies of Nurses fall into dangerous sicknesses, from excess
of

6.

Blood is nor a fit, nor possible Matter, for the generation of Milk.

The Journey of the Chyle.

of blood, soon after they cease to give suck; because being long accustomed to the generation of so profuse a quantity of blood, for the supply of their milk; and that daily evacuation thereof ceasing, the whole body must needs be oppressed with that redundancy: but, they seldome complain of any *Plethora*; therefore &c. (7) If blood, not chyle, were the matter of milk, then were it impossible the milk should retain the odour and qualities of the meats eaten; since no manifest quality of the meat can be apprehended in the blood, much less in what is generated of blood, as being one remove further from it: but the Milk doth frequently retain the odour and other qualities of the meat and drink; Ergo. This is attested by the experience of Physicians, who give purging medicaments to Nurses, when there is cause to purge their children. *Prosper Martinus*, the best Commentator upon *Hippocrates*, hath an observation of a woman, who having taken a purge, soon after gave her child suck, and thereby endangered the child's life, a superpurgation ensuing in the child, while herselfe felt no effect of the medicament at all. No obscure argument, that the Milk deriveth its purgative faculty from the Chyle, not from the blood; for if it were to be carried so long a journey, as through the heart and arteries, and therein undergoe so many and great changes: doubtless the virtue of the medicine would be much weakned and dulled; nor could it be derived into the paps, so soon after it was first received.

Comment in
lib. *Hippocr. de*
nat. pueri.

received into the stomach. Here may we fea-
 sonably recite that saying of *Aristotle*, *Si la-* 7. *De hist. A-*
ctans pilum cum cibo aut potu ingerat, ad mammas nimal. cap. 11.
pervenit, & in earum papillis consistens, morbum
inducit, qui τεξιλας nominatur: and that rare
 observation also cited by *Martianus*, of a piece *Loco. citat.*
 of a root of Cichory eaten in sallade by a nurse
 at night, and taken out at one of her nipples
 the next morning. But, above all, this Expe-
 riment is most convincing. Let a nurse drink a
 good draught of milk tinged with Saffron; and
 within an hour or two after express the milk
 out of either of her paps, into a glasse or other
 small vessell: and that milk shall have the o-
 dour, sapour, yea and the very colour also of
 Saffron. (8) Nor is the Milk made of the Men-
 struous blood, as some Philosophers have
 dream't; because many bruit Animals have
 milk, that never suffer the monthly flux; be-
 cause most new-born infants have some milk
 in their paps, as *Dr. Harvey* hath well remar- *De gen. anim.*
 ked; and because even Men themselves have *exercit. 55.*
 been found with good plenty of milk in theirs
 also. *Schenchius* affirms, that he knew one *Lau-*
rentius Wolfius, who from his youth to the 50
 year of his age, had abundance of milk flow-
 ing out of his duggs every day. The like is af-
 firmed of a certain Flemming, by *Wallæus*; and
 of divers others by *Cardan*, by *Benedictus*, by
Aquapendens and other credible Authors. Nay,
 Historians report, that in *America* there are
 whole nations, among whom the men gene-
 rally abound with milk, and suckle their chil-
 dren.

dren. To which we may adde, that many nurses have their Termes, while they give suck, and yet find no diminution of their milk, at those times, more than at others. So that we see, how unreasonable it is to conceive, that blood is the matter of Milk.

7.
Milk and
Chyle agree in
all their mani-
fest Qualities;
and are reci-
procally con-
vertible.

Thirdly, Milk and Chyle seem to be one and the same thing; as may appear both by their mutuall agreement in all their qualities, and by their easie reciprocall convertibility. As for their *resemblance in manifest qualities*; (1) They both have a fatty substance: otherwise neither could be fit either to sustain the Lamp of life, or to instaurate the parts; nor can the blood contain any such fatty substance in it, but what is derived from the Chyle. (2) As Milk doth consist of two parts, the *serum* and *crassamentum*; so likewise doth Chyle, whose *serum* is dreyned away by the kidneys, and *crassament* by the guts. (3) As Milk, if kept over-long, especially in a warm place, or corrupted by any Acid juice, doth turn fowr; so also doth the Chyle, and in the stomach of Calves is found a certain fowr serum, which housewives use for the coagulation of their Milk; in like manner the same is frequently generated in the stomachs of men, which being ejected by vomiting, sets the teeth on edge; having acquired that fowrness either by corruption from excessive heat, or by the admision of a melancholy juyce. (4) They are equally sweet in tast; which is the reason, why many brute Animals lick up the

the milky liquor flowing from the secundines, when they bring forth their young, which is indeed the nutriment of their young, while remaining in the womb. (5) They resemble each other in colour, being both white; as the sense testifieth. (6) They both contain certain small Fibers, that seem to be educed from the more viscous and glutinous parts of the aliment. And these, doubtless, are those Fibers, which sensibly uniting themselves in the superfiice of blood let forth into a cold vessel, appear in form of a whitish film, or thin skin; long mistaken by Physitians for cold, viscid and phlegmatique matter commixt with the blood: and if the red parts of the blood be gently washed away from them, they become distinctly visible. And as for their *reciprocal Convertibility*; that is clearly proved by this, that Chyle is easily converted into milke, in the Nurse; and that milk again converted into Chyle in the stomach of the Infant that sucks it. Now these many resemblances considered, we may safely conclude, that they have much more of reason on their side, who conceive Milke to be nothing but meer Chyle brought from the stomach to the Paps, by peculiar passages; and therein promoted to somewhat more of perfection: than they, who think it to be made of blood whitened in the glandules of the paps.

Having, with so great verisimilitude, brought Chyle from the stomach to the Paps, for the sustenance of the infant, after he is born;

8.
That Chyle is
imported also
into the womb,
in pregnant
women.

E

it

9.
From the Au-
thority of
Hippocrates,
&

lib. de Natur.
pueri.

it remains now that we see, whether any portion thereof be deduced also to the *womb*, for his nourishment before he is born. First, therefore, let us seriously consider, what light hath been anciently given to this obscure disquisition, by that Genius of Nature, *Hippocrates*; who hath fundry pregnant Texts to this purpose.

Uterum foetu grandiore (saith He) comprimere mulieris Ventrem, & quod in cibo potuque est pinguiissimum & candidum, magisque uteri calore dulcoratum, in mammas tendere, & in uteros quoque exiguum portionem per easdem Venas deferri. In which words the reverend Author toucheth upon two things very considerable and pertinent. (1) That the fat, white, and sweet Chyle is carried up to the paps, by compression of the *Venæ Lactææ*, and the common Receptacle of the Chyle; the swoln womb being incumbent upon them, and pressing the Chyle upwards. For, that Compression cannot be understood of the veins and arteries in the lower belly, as if they were thereby urged to disgorge their blood into the paps, for the generation of milk; because, a compression of those veins and arteries, that are near the *Vertebræ Lumborum*, would necessarily hinder the course and recourse of the blood, requisite to the work supposed. But, as *Perquet* will have the weight of the Liver, moved up and down in respiration, to conduce to the compression of the stomach, *venæ lactææ*, and receptacle, from the upper part of the abdomen: So will *Hippocrates*

hipocrates have it, that, from the lower part, the compression of the womans belly by the greatnesse and weight of the child, doth cause the Chyle to alter its course (his words, in another place, being, *convertitur ad mammas*, *quod est dulcissimum ex humido*) and flow upward to the paps. Thus the Scythians, as *Herodotus* reports, had a trick to blow up the wombs of their Mares, by certain *sufflatoria ossa*, like pipes, to the end that their bellies being compressed by the swelling of their wombs, the greater abundance of Chyle might be protruded into their udders, and so their milke increased. (2) Since by reason of the same Compression, the passage of the Milk, by vessels tending from the paps to the womb, is not so open and free, as while the burthen of the womb was lesse ; thence it comes, that so small a quantity of the Chyle is imported into the womb, as will not suffice to the nourishment of the *Fœtus*. Much Chyle, therefore, flowing to the paps from the *Venæ Lactææ*, and the Common Receptacle ; and some milk also re-flowing from the womb to them, by reason of this Compression mentioned : it is no wonder, if the paps at that time swell above measure ;

A second memorable place of *Hippocrates*, *lib. citat.* to this purpose, is that ; *Ad mammas enim & uterum ejusmodi venulæ, & consimiles, feruntur. Cumque ad uterum pervenerit, lactis formam habet, eoque exiguo puer fruitur : mammae vero, ubi lac exceperint, attolluntur & implentur.*

A third, to the same effect, is this ; *Fœtus quod in sanguine dulcissimum est, ad se trahit, simulque aliquantulâ lactis portione fruitur.* Where He hinteth the true cause, why it is unwholesome and dangerous for Infants to suck women with child, viz. because the best of the milk is attracted by the Fœtus, in the womb, and the worst is carried to the paps. Which He more expressly declares in these words, *Dum mammae exsuguntur, venæ quæ ad eas tendunt ampliores redduntur, & ampliores effectæ quod pingue est è ventre attrahunt, & in mammas transmittunt* : giving the reason, why the fat and richer parts of the milk do not ascend to the paps, till after the birth of the child, who by frequent sucking doth dilate and amplify the vessels (formerly too small) through which the milk is to pass from the womb to the paps, and so make them more capable of the thicker liquor ; and hence, doubtlesse is it, that the milk in womens breasts is alwaies much thinner and wheyish, while they are with child, than after their delivery.

10.
Of Dr. Harvey.

*Exercit. de
Uteri membranis
& humoribus.*

From Hippocrates the First, let us go to Hippocrates the Second, the immortal Dr. Harvey ; who, by frequent dissections of prægnant and suckling Animals, discovered that there is Chyle or milk imported into the womb. For, describing the Cotyledones or *Acetabula* of the womb, He saith ; *Cavitates istæ spongiæ majoris loculamenta magnitudine non excedunt ; inque singulas earum, totidem vasorum umbilicalium ramuli tenuissimi profundè penetrant : quippe in iisdem*

dem alimentum fœtui reconditur ; non quidem sanguineum, sed mucosum, ovique albumen crassius planè referens. Unde etiam manifestum est, bisulcorum Animalium fœtus (ut & alios omnes) sanguine materno non ali. And, in the subsequent paragraph, He adds, coarctatis hisce acetabulis, non sanguis, sed albugineus liquor emanat ; eodemque expresso, illa statim contracta, albidiora, & flaccida conspiciuntur ; ac demum mammarum papillas, aut verrucas pensiles majores referunt : And a little after, Opinor, carunculas omnes (uberum modo) non sanguinem, sed succum albumini similem concoquere, eundemque fœtui subministrare. Again, in another place, tracing the way of this milky juice more accurately, He saith ; ab utero per cotyledones pertingit ad carunculas placentæ ; quas quidem si digitis compresseris, ex earum una aliqua (tanquam ex papilla) succi istius alibilis facile cochlearis mensura emulgetur : idque nullo apparente sanguine, quem attractu etiam valido, nunquam elicueris ; quin etiam caruncula sic emulsa atque inanita, compressæ spongiæ instar contrahitur & flaccescit ; plurimisque foraminibus pertusa cernitur. Adeo ut omnibus indiciis pateat, carunculas istas esse ubera uterina, sive albuminis nutritii conceptacula. And a little after, He expressly affirms, succum illum in Gravidis ante partum, in acetabulis conservari ; post partum verò, ad mammas deferri. Than which nothing can be more plain, more positive.

To the Authorities of these great men, let us adde the consideration of that great Sympathy or consent betwixt the womb and paps, II.
And from the
sympathy be-
twixt the
womb and the
paps.
so

so frequently observed in women. Which Consent cannot be caused by nerves, nor by veins, nor by arteries, nor by similitude of substance, nor by contiguity of situation; and therefore most probably, by mediation of these presupposed Chyliferous vessels tending from the paps to the womb. (1) Not by *Nerves*; because the paps derive their nerves from the fourth intercostall pair, or the fifth pair of the thorax: and the womb is supplied with sense from the nerves of the *os sacrum*, and also from the sixth conjugation of the brain. (2) Not by *veins or arteries*; because they are, both, destitute of sense, as *Galen* himself affirms. (3) Not by *Similitude of substance*; because the paps consist mostly of Glandules, and the body of the womb is membranous. (4) Not by *Contiguous situation*; because the paps and womb are far distant each from the other. It being, therefore, most certain, that all sympathy betwixt parts of the body, doth arise either *ex Vasorum Comunione*, or *ex operis societate*, or both; and that betwixt the paps and womb there is no communion of vessels, unlesse it be of some chyliferous vessels derived from those to this; and that there is a society of office betwixt the paps and womb, both containing the Aliment of the child: it is highly consentaneous to truth that there are such vessels (though yet undiscovered) by which the Chyle is carried from the paps to the womb, while the infant remains therein, and back again from the womb to the paps, after he is born. This being granted, we may

may cleerly understand the wayes and manner of the ascent of the milk from the womb to the paps; and the reflux of it from the paps to the womb, so frequently mentioned by *Hippocrates*. We may understand also, how the good or evill affections of the womb are communicated to the paps; and how it comes, that a Cancer cured in the paps, doth revive and grow again in the womb, and *vice versa*. And thus may we understand those Aphorisms of *Hippocrates*; *Si gravida mammae graciles fiunt, repente illa abortit; si gravida lac multum è mammis effluit, foetus imbecillum significat; si solida mammae, foetus saniozem*. In respect of these vessels, are we moreover to interpret that Rectitude of consent betwixt the papps and womb, intimated in that Aphor. *Gravida gemellos gerens, si dextera mamma fiat gracilis, marem; si verò sinistra foeminam abortit: foetus enim mares in dextris, foeminae in sinistris magis*.

To conclude this Disquisition, therefore, since it is manifest that there are some such Chyliferous vessels, or *ductus*, by which the paps and womb have a reciprocall commerce; it is not improbable, they are derived from the extremities of the Chyliferous veins of the thorax, where those enter into the subclavian veins, or the branches of the *vena cava*; being disseminated on each side one, to each pap; whereunto so soon as they have insinuated themselves, and dispersed several small furcles, to lead a long the chyle to the nipples, they may be conceived to emit others branches

12.
A conjectural description of the Chyliferous vessels tendin from the paps, to the womb.

ches downward along the abdomen, that insert themselves into the womb, on each side one; and perchance some one also into the bladder, it having been observed, that Chyle hath been avoided by urine. But, what need we thus anticipate, by conjecture, when we daily expect the discovery of the wayes through which they passe, by Anatomists, who now a dayes exercise themselves in strict enquiry after them?

OF SANGUIFICATION.

Exercitation the Fourth.

Of Sanguification.

Article

I.

The most part of the Chyle is converted into blood.

FROM the smaller and lesse conspicuous Rivulets of the Chyle, we now come to survey the grand and plainly visible Current thereof; which being imported (as we formerly declared) into the subclavian veins, from them into the *vena cava*, and thence immediately disembogued into the right ventricle of the heart, is therein converted into a liquor of a different colour and nature, *viz.* Blood, for the fewell of the vital Lamp, and the continual refectiō of spirits vital. And here we are (for method's sake) in order to consider (1) The *Mutation* which the Chyle arriving at the heart, doth therein suffer, or the Action its self,

self, called Sanguification; (2) *The Agent*, or principal Efficient of that Mutation; (3) *The Manner* how it is effected; (4) *The Uses* of the Blood, after it is made; (5) *The Motion* of the same, in order to those uses.

Concerning the *FIRST*, viz. *the Action of Sanguification*; we advertise, that it is not an ^{2.} Organical action, or such as depends upon the peculiar constitution, or fabrique of any Organical part of the body; but meerly a *Similar* one. For, since the blood, when made, is a similar body; and the Chyle of which it is made, is likewise a similar body; and that the Chyle doth not become blood, by separation of any one or more parts of it, from any other (as the Urine and Bile are made) but only by a kind of Exaltation of its nature, or an advance of those Natural spirits it containeth, into vital or more sublimed and active ones, while the vital spirits, præexistent in the Ventricles of the heart, do enkindle the same heat, and cause the same diffusive or expansive motion in the Natural, which themselves have formerly acquired: we say, considering these things, it is manifest, that the work is done by *simple Assimilation*; and consequently that Sanguification is an *Action similar*, not Organical, as hath been long erroneously affirmed.

Concerning the *SECOND*, viz. *the Efficient*, let us first examine what that cannot be; and so we shall the more easily and certainly find what it must be. The prime Agent, or Author
F of

of the work of Sanguification, is not either the *Liver*, as *Galen* and his Sectators conceived and taught; or the *veins*, as some Anatomists have dreamed; or the substance of the *Heart*, as *Aristotle* and his Disciples have asserted; or any other organ of the body.

3. To be more particular; we affirm, the *Liver* not to be the Agent in the work of Sanguification; and that for sundry reasons. (1) No part of the Chyle is brought to the Liver, by any one or more of the *Venæ Lactææ*: they in the lower belly generally exonerating themselves into the Common Receptacle; and those in the Thorax being terminated in the subclavian veins: and therefore it is impossible the Liver should transforme chyle into blood, when no chyle can arrive thereat. (2) There is blood to be seen in an Embryo, before even the very rudiments of the Liver are delineated; and what hath been before, cannot be the effect of what hath no being till afterward. That the blood hath priority of existence, is manifest from the observations of Dr. *Harvey*, who expressly affirms, *Sanguinem dari, antequam quicquam corporis reliqui existat; esseque eum, præ cæteris omnibus fœtus partibus, primogenitum; & ab ipso, tum materiam, ex qua corporatur foetus, tum nutrimentum, quo augetur, procedere; esse denique (si modo ulla fuerit) primam particulam genitalem.* (3) After the Chick is perfectly formed in the egg, and hath its veins and arteries replenished with blood; yet doth the Liver still remain pale and whitish,
not

Whose Primary Efficient, is not the Liver;

de gen. Animal.
exercit. 18.

not without some small tincture of yellow, which observation doth of it self alone demonstratively depose the Liver from the office of Sanguification, and conferre that dignity upon some other Agent. For, how can the Liver, supposing the Chyle were brought to it, give a deep redness thereunto, while it self yet continueth white? Can any thing give that to another, which it self hath not? This also is certified by the experience of *Dr. Harvey*, who thereupon firmly concludes; *jecur & calorem, exercit. de gen A. & colorem suum à sanguine mutuatur; non autem nimal. 51 sub sanguis à jecore.* From hence it may be observed, *finem.* that the native colour of the Liver is not red, but pale, with a faint mixture of yellow; and that, what redness it doth afterward acquire, is communicated to it from the blood continually percolated through the parenchyma of it. Both which may more plainly appear by this, that in a Chick not yet excluded from the shell, that yellow paleness of the Liver is visible, even the very last day of the Hens incubation; though at that time the same begins to incline toward some degree of redness, which is more and more augmented every day after the chick is hatched. Again, if you fill a bladder with warm water, and through a slender pipe inject the same, by the trunk either of the vena Cava, or vena Portæ, into the Liver; and so rinse out the blood remaining in the vessels and substance thereof; you shall sensibly perceive the redness of the Liver to vanish away, and a certain dusky or sooty yellownesse succeed in

the room. Which obscure yellownesse, doubt-
 lesse, hath its original meerly from the tincture
 of Choler. However, most certain it is, that
 the Liver hath natively no redness at all; and
 what it afterward contracteth, is adventitious,
 and from the blood. To this purpose is that
 easie experiment of Dr. Harvey; *imò verò je-*
cur, lien, renes, pulmo, & cor ipsum (si sanguinem
inde omnem expresseris, cujus præcipuè gratia vis-
cera dicuntur) expallescent illicò, & partibus fri-
gidis accensenda sunt. So that we may with
 good warrant conclude, that the office of San-
 guification was, by the Galenists, assigned to
 the Liver, rather upon inconsiderate partiality,
 than any right at all.

4.
 Nor the veins.

(2) Of the *veins* also the same may be said.
 For, if that rule of *Galen* holds true (as cer-
 tainly it doth); *Quod mutatur, in ejus speciem, à*
quo mutatur, facessit; the veins can never be
 thought fit, to transform the Chyle into blood.
 For, their Colour is white and somewhat trans-
 lucid; their substance viscid, membranous,
 and bloodless; they have no parenchyma, and
 very little either of heat or spirits of their own:
 whereas, on the contrary, the Blood is of a
 deep red, not translucent, of a substance fluid
 and interminate, and abounds with heat and
 spirits. And, therefore, it were vain to expect
 an Assimilation, where the supposed Agent
 and Patient are of natures in all things so in-
 compatible, so contrary. We deny not, that
 the veins in some respect conduce to the Con-
 servation of the blood; but how? Only as they
 are

are Organs, inservient to the defence of it from external injuries, and the reduction of it from the parts upon which it was newly affused out of the arteries. And as for any similar Action of the veins upon the blood; they have none at all: yea, their office of Conserving it doth consist chiefly in their inactivity, *i.e.* in this, that they are not apt to alter or deprave it; as Glass-vessels are the best to conserve liquors in, because they neither communicate any ill qualities of their own, nor permit the like to be communicated from others to them. But, that which doth principally conserve the blood in the purity of its nature, is the very same thing that makes it from the beginning, *viz.* the *vital Heat and Spirits derived from the Heart*, which by their enlivening warmth, and continuall motion, do not only vindicate the blood from corruption, but also all the solid parts of the body, and so even the veins themselves also, as long as the Lamp of life continueth burning. And that being once extinguished; how soon, alas! do all parts of the body yeeld to the quick tyranny of corruption?

(3) Nor hath the Heart more right to this noble office of Sanguification. For, that bor-^{5.}rowes all its vital heat and activity meerly from the vital blood contained in its ventricles, and distributed into its substance by the Coronary arteries. Of which vital influx were the Heart deprived, but for some few moments; it would soon become as torpid and motionless, as any other part of the whole body; so far

Nor the Heart:
but the *vital*
spirit, residing
in the blood.

far is it from exalting the Chyle into so noble a Nectar, as the blood is, by any similar action of its owne. To assure this, please you, take out the yet-panting Heart of any the strongest and soundest Animal, and having with warm water rinsed all the blood out of the ventricles, fill them again with warm Chyle or Milk; and see whether it will be able to convert the same into blood. Certainly, you shall find none the least change to be wrought upon the liquor infused. Yet the Heart is a solid and strong part; and one would scarce think it probable, that that action, which it is supposed to performe, by reason of its solid substance, should be intercepted in so short a space of time. Forasmuch, therefore, as the Heart doth, in a moments time, surcease its activity, and desist from the work of changing Chyle into blood, as soon as the vital blood is effused out of its ventricles; it is as manifest, as certain, that the virtue Generative of blood, is not radicated in the solid substance of the Heart, primarily, but in something else, *viz.* in that very thing, upon whose absence immediately that virtue is destroyed, which is the vital Blood. Again, the dissection of Living Animals teacheth us, that the vital Heat is much greater in the ventricles, than in the substance of the Heart: and Reason biddeth us thence to infer, that the same Heat is originally in the ventricles, and but at second hand, or by way of communication, in the parenchyma. Now, if the Activity of even the Heart it self, be derived

rived originally from the vital Blood ; and that the vital Blood be more powerfull than the Heart : we can hardly deny the same to be the Primary Cause , or Agent of Sanguification ; unless (at least) it shall appear , that the vital blood is less apt for such a work, than the Heart. But , comparing the agreeableness of the Heart to such an office, with that of the vital Blood to the same ; we shall quickly perceive which of the two hath the greater. For, the vital Blood is of the same species with the thing to be made or produced ; but the substance of the Heart is far different from it. It being, therefore , canonical, that all Naturall Agents endeavour, according to their energy, to assimilate to their own nature the thing, upon which they act : it seems of equal certainty, that the activity of the vital Blood, is most properly consigned to the work of Sanguification. A further evidence of this, may be drawn from hence, that the Chyle and Blood are most *intimately mixed* together in the ventricles of the Heart ; while the Chyle doth only *superficially* and *in transitu* touch the sides of them. To which may be added, that the Chyle makes but a very short stay in the Heart: but remains constantly commixed with the Blood, untill it be thereto perfectly assimilated. Lastly, the blood flowing in the heart, arteries, and veins, doth exceed the Chyle of one meal, in quantity at least ten times, and in strength or activity, an hundred ; (for, what is more potent, then that spirit, which enliveneth the whole body ;
what

what softer, gentler, and more easily superable, than Chyle?) and therefore, no doubt but the Bloud doth easily obtain the victory over the Chyle, and over-run it with his own nature.

7.
which alone
formeth the
blood in a
chicken, out
of the *Colliqua-
mentum*.

To secure this Assertion from all doubt whatever, let us have recourse to the observations of *Dr. HARVEY* (the true Oedipus in all abstrusities of this kind) of the progress of Nature in the generation of the parts of an Animal successively one after another; and we shall soon be satisfied, that the First Bloud is made by the vital spirit. That great man attesteth, that the white of the Egge doth for some dayes after the Hen hath sat a-brood upon it, retain its native whitenesse, and that out of the *Colliquamentum*, or White, made more thin and fluid, the Chick is generated, without the addition of any other matter. The Question then is only this, *How that white colour in the Colliquamentum, or so much of it as the Plasticque faculty converts into blood; comes to be changed into red?*

Certain it is, this cannot be effected by any thing that was red before; because there is no part of the Egge of, or inclining to, that colour; and the yelk remains intire a good while after there is bloud to be seen in the *punctum saliens*. Nor is it the Fleshy parts, that communicate this vermillion tincture to the bloud, because they remain white after the bloud is made out of the *Colliquamentum*: and it is much more reasonable, that the fleshy parts
derive

derive their rednesse wholly from the bloud, perpetually irrigating and washing them in its Circulation. For, their rednesse grows upon them by degrees, and that sooner or later, according to the degrees of Heat impressed upon the Egge by the Hen, and according to the greater or lesse quantity of bloud arriving at them. Some parts, which are but lightly touched by the bloud, never become red; in which account are the coats of the Eyes, the Ligaments, Tendons, Membranes, Bones, &c. Others obtain a certain palenesse dashed with a sparing mixture of red; as the Glandules which as they are furnished with greater or smaller arteries (respective to their magnitude) so are they tinged with more or lesse of rednesse. The Musculous flesh is more deeply dyed with scarlet, than the Glandules; as being irrigated with greater streames of bloud. The Kidneys, Liver, Spleen, Lungs, and Heart, are all washed with full streams of bloud; and therefore have a deeper dye of rednesse, than any other parts: and yet are much lesse red, than the bloud itself. Now it is more reasonable to conceive, that the Greater should communicate its virtue to the Lesser, than on the contrary, the Lesser to the Greater. For, how can any Natural Agent operate beyond the sphere of its activity, *i. e.* the measure of its power? or communicate that to another, which it self wanteth? Again, nothing can have an activity, before it hath a being: and consequently the solid parts cannot give a red-

ness to the blood, because they are not in being, till after the blood. Nothing, therefore, remains to be the Efficient of the Blood, but the *Vital Spirit*, kindled originally in the purest part of the seminal matter, or *Colliquamentum* which we may well denominate the *Vital Liquor*.

8.

The Manner
how blood is
first generated
in an Embryo,
by that *Vital*
Spirit.

Concerning the *THIRD* considerable, viz. the Manner of this grand operation of the *Vital Spirit*; though it be very obscure, yet doe we not think it altogether inexplicable, if we deduce the blood from its first Origine, the newly mentioned *Vital Liquor*. This *Vital Liquor*, before it assumes the colour and forme of Blood, doth begin to separate it self from the other parts of the Egge (to which it is at first promiscuously admixed) and to runne its selfe out into certain slender rivulets, or branchings, which afterward become Veins. These rivolets concurring in a point, meet altogether at the centre of the *Colliquamentum*; which centre being the principal seat of the Plastique spirit, and acquiring a certain mication, or pulsation, is then called *Punctum Saliens*? And all this is done, before there is any the least appearance of blood in the Egge. So soon, therefore, as these Rivulets are conjoyned, the Flux of the *Vital Liquor* is, for some time, so hindered by, and repressed in them, as that being indefinitely agitated by the *Spirit of Life*, it æstuateth, and indeavours to expand it self and enlarge its bounds: and seeing that it cannot flow back againe toward the circumference,

rence, by the same passages, which brought it toward the centre, by reason of fresh supplies of *Vital Liquor* pressing it forward continually in the course begun; it is compelled to force it self again into the seminal matter, from whence at first it began its motion, through other slender conduits newly for that purpose formed, and then it begins to flow in a round. For, this appears to be the true reason of the *Circumgyration* of the *Vital Liquor*, from the very beginning. Soon after this, the Rivulets or pipes first made, and leading from the circumference to the Centre, become *Veins*; and the others made in the second place, and leading from the centre to the circumference, become *Arteries*: which yet others disallow, in respect of the fabrick of the valves) and then in the poynt of their concurrence or confluence, the *Heart* is framed. Through which Heart, and the conduits annexed or (rather) continued unto it, the one sort tending toward, the other from-ward the centre; the *Vital Liquor* doth (while life lasteth) perpetuate its motion: and at the same time irrigate and vivifie all parts of the matter, which it continually washeth in that its circular course. Now this *Circulation* is begun, for some time before the *Vital Liquor* is excocted into blood; as may be conceived from hence, that when the motion of the *Punctum Saliens* is plainly visible, there is no blood, but only a clear, transparent liquor, or (as the Learned *Harvey* call's it) the *Colliquamentum*: and also from hence, that while

the *Seminal Matter* is yet thin and fluid, the *Vital Liquor* can easily disperse its channels through the same ; there being then no impediment to that its expansive motion, and operation : but, if it should defer its dispersion and making of rivulets, til after the solid parts were made; 'tis hard to conceive, how it could be able to shoot it self forth into branches, and make its way through them.

9.
and in what
part of the
Conception it
is first genera-
red, viz in the
Chorion.

This *Dance of Life* being thus begun, though no *Bloud* yet appears, yet soon after it doth appear ; the *Vital Liquor*, while continually (though slowly) circulated, by little and little assuming the form of *Bloud*. And the place in which the *bloud* first shews it selfe, is the *Chorion* ; not the *Heart*. For, seeing that the *Chorion* ought to be made solid and firme, before any other of the parts of the *Conception*, insomuch as it serveth as well for the safeguard, as nourishment of all the other parts ; and that to this end, there is no moisture coming from without, that might hinder its being made solid ; and that the *Chorion*, as involving the whole conception, is the first part that receiveth the warmth of the *Hen*, during her incubation : we say, from hence it comes, that the *vital Liquor* doth first of all obtain the forme of *Bloud* in the *Chorion*. And this is effected the sooner, because the *vital Liquor* doth more easily emit its exhalations, in that place, as being in the circumference, than in any other more remote from it : and unlesse those exhalations were freely emitted, the
Spirits

Spirits of the *Vitall Liquor* would inevitably be soon extinguished. It is moreover probable, that at this time, the Vital Heat is more potent and active in the exterior parts of the Conception, than in the Centre ; and so, that the First Blood is made in the Chorion, where it first discovers it self to the sight of the inspector. Hence also we may observe, that because there is no blood to be discerned in the *Punctum Saliens*, for many hours together after blood is discernable in the *Chorion* : therefore, must the Circulation of the blood be exceeding slow in the beginning; for, as soon as the blood, that is in the *Chorion*, performing its circular motion, arriveth at the Heart, it cannot but be discerned in the *Punctum Saliens*.

Now, these observations being undeniable, we may safely assert ; that the *Vital Spirit* in the *Seminal matter*, being excited and assisted by the external heat of the Hen sitting upon the Egges; and by degrees becoming active, and infusing heat into the vital Liquor, wherein it doth reside : doth thereupon, in proceſſe of time, induce the colour of blood ; and that only by means of its vital Heat and Motion ; and that no other part is to be reputed for Principal Agent, in the work of Sanguification. Nevertheſſe, we do not hereby exclude *Concurrent extrinſecal Agents*, or *Causes* : but into that account readily admit the Hen, whole warmth at first both excited and assisted the *Vital Spirit* in the work of Sanguification; and the

IO.
In the generation of Blood, what are the Concurrent Extrinsic Causes : and what the Accessary Organical.

the substance of the Heart it self, which afterward conduceth in some sort to the same. Nor do we repudiate *Accessory Organical Causes*; as the *Fabrick of the Heart*, the *Arteries* and *Veins*, all which are inservient to the continual motion of the blood. Only we affirme, that *the Vital spirit*, by reason of its *Heat and Motion*, hath a just right to the dignity of *Principal Agent*, in making of Blood.

II.
The Conversion of the *Colliquamentum* into Blood, by the heat and motion of the *Vitall Spirit*; illustrated by sundry analogous *Experiments*, and *Observations*.

We say, *By reason of its Heat and motion*. For, that Colours frequently are advanced from a white, or pale, to several kinds of Red, meerly by Heat and Motion; is demonstrable by sundry easie and familiar Experiments. Our Confectioners well know, that long boyling of Quinces and other Fruits doth give them a ruddy colour. So likewise Fruits baked in an oven, are more inclined to redness, than while they were raw. The same is true also even of Flesh, and Bread, which by baking or roasting, acquire redness in their superficial parts: and some Chymists affirme, that a Tincture of Bread will assume a certain degree of redness, after long digestion. This is not, we acknowledge, common to all Liquors, especially simple ones; for simple waters, and such as are destilled, suffer little or no change of colour, upon decoction, though long. But generally all Compound Liquors, especially if they contain any Nutritive juice, in competent quantity, and have besides any touch of salt, or Acid spirits in them: are observed to acquire a sanguine tincture, by decoction. Upon which fertile hint,
as

as we conjecture, that highly Learned, Industrious, and Acute Person, Dr. ENT, seems to have grounded that ingenious opinion of his; that the Redness of the Blood ariseth *ex Aciditate spiritus vitalis salinei*, from the *Acidity* of the vital spirits, having their original from a certain seminal salt. However, we have good reason to perswade our selves, that all vital Liquors, i.e, such wherein the vital spirits of Animals do reside, are apt to acquire more or less of redness; provided they obtain sufficient Heat, and agitation or strife in their motions. This is evident in all Sanguineous Animals, in which the Chyle is first white, and after changeth into blood. And as for Exsanguious Animals, they also give some testimony of this truth; as may be instanced in Oysters, in which blood is frequently found (and yet without a prodigy) in summer time, by reason their vital Heat seems then to be augmented: and in winter, when their Heat is again lessened, below what is requisite to induce redness, their vital juice is alwayes whitish. To return to sanguineous Animals; as they are generally hotter of constitution, than Exsanguious; so are their Sanguine parts alwayes hotter, than their pale and white parts. In like manner, in cold diseases, as the Green sickness, Cachexy, Dropsy, and in all Phlegmatique constitutions, the blood is paler, than in hot diseases and constitutions. Again, the venal blood, as it loseth the heat, which it had acquired in passing through the heart and arteries; so doth it

propor-

*in Apolog.
pro circulatione
sanguinis, ad-
vers. Parisan.
p. 119.*

proportionately by little and little lose that florid and deep scarlet dye, that it had in the heart and arteries. For, blood let forth of a vein, appears blewish, and comes short of that lively fresh scarlet, that is observed in blood effluxed from an Artery. All which clearly shew, by whose efficiency it is, that the vital juice (in Sanguineous Animals) is excocted into Blood; and what conserves the same in its primitive purity and lustre: *viz.* the *vital spirit* continually renewed in, and enlivening the blood; for, that being once extinguished, how soon doth the blood degenerate into *Cruor*, and lose its fresh scarlet tincture?

I 2.
That the same Agent, which maketh the first blood in an Embryo, doth make it ever after in an Animal, during life.

Having thus investigated what that is, which makes the *First Blood* in an Embryo, by converting the *vital Liquor*, from a white, into a purple Nectar: we cannot be long in exploring what that is, which in *Animals* maketh blood all the life after, by converting the *Chyle* likewise, from a white into a red liquor. It is an infallible rule, you know, that the *identity of Effects* dependeth upon the *identity of Causes*; because an effect is not supposed to be, untill it hath obtained existence from its proper causes: and at the same time the causes give that existence, they cannot but give also the identity belonging to it. All which is imported in that common Axiome, *Idem, quia idem, semper facit idem.* For, though *Free and Arbitrary Causes* may act at liberty, and, by varying the manner of their operating, vary also their effects: yet *Natural* ones are bound up to a determinate mode

mode of energie, and must, as long as they continue the same, act after one and the same way, and so produce invariably the same effects. Forasmuch, therefore, as the Efficient of the First Blood, is an Agent *Natural*, and not Arbitrary; if it continue the same in an Animal, while the Animal lives, it must of necessity continue the same operation. That it doth continue the very same, during life, is most certain; because it is the Principle of life, nor can life subsist for so much as one moment without it. Nor doth this Efficient of Blood only persist the same in the body, that it was at the first conception; but grows every day more vigorous, potent and fit for the work, untill the Animal hath attained to the flower of his age: and to imagine that an Agent Natural (such as the Vital Spirit) should at any time become idle, intermit its operation, and not exercise all its forces; is grossely absurd. Conclude we therefore, that the Vital Spirit, as it is the Efficient Cause of Sanguification, in the Embryo from the first Conception; so is it constantly Author of the same work, untill the Animal dieth.

OF THE USES OF THE BLOOD.

Exercitation the Fifth.

Article. 1.

That the Bloud
is not the Ge-
neral Nou-
rishment of the
body. Because

IT followeth now, that we enquire, *To what End Nature* hath consigned so continuall a province, as this of Sanguification, to that subtile Agent, the Vital Spirit; or, more plainly, of what Use the Bloud is, in Sanguineous Animals. Concerning this, there are (for ought we know) but *Two opinions* extant; the *One*, that *the Blood is the general Nutriment of the body*, or Matter by which the substance of the parts is daily instaurated; the *Other*, that it *serveth both for the maintenance of the vital Flame, which cannot subsist without a perpetual supply of convenient fuel; and for the refectiō of vital spirits.* The *Former*, though very antient, and generally embraced; yet (in our judgment) deserveth to give place to the *Latter*: because though the *Latter* be new, and as it were of but yesterdaies standing, yet it hath much more of probability, as may be evinced by these ensuing Arguments.

2.

The contrary
opinion is sub-
ject to sundry
both inexpli-
cable difficul-
ties, and irre-
concilable
incongruities.

(1) It is well known, that *Aristotle*, in many places of his works, hath earnestly contended, *Sanguinem esse ultimum totius corporis alimentum*, that the bloud is the ultimate, or most perfect Aliment of the whole body: and that the whole School of *Physicians* hath given its suf-
frage

frage to verifie that his Tenent. And yet many things, not easie to be explicated, and lesse easie to be reconciled one to another, may be observed to attend thereupon. For, *Physicians*, when, in their Physiological discourses, they treat of the nature of the Bloud and endeavour to make good, that it serveth to no other use, but only to afford Nutriment to the body; they suppose it to be a substance, not simple and homogeneous, but mixt and compounded of Four severall juices, promiscuously flowing together in the same streams: deducing their principal argument hereof, from the Combinations of the Four First Elementary Qualities (as they call them) and accordingly teaching, that the ingredients of bloud are the two sorts of *Bile*, or *Choler* (*viz.* the yellow, and the blackish) *Phlegme*, and *Blood* properly so called. Further, of each of these different humours; They make some *Nutritive* (as assuming the whole body to be made up of them) others *Excrementitious*: and then They decree, that the bloud doth consist of those diverse Nutritious humors, as of Heterogeneous parts. After, though they allow the Phlegme to be the colder and cruder part, and so capable of conversion into good and laudable blood, by more intense heat, and longer concoction; and likewise allow the Choler to be convertible into Melancholy, by adustion; and blood to be convertible into both choler and melancholy, by the same means: yet will they by no means admit of a regression of either Choler or Melancholy

into blood. Now, if these things be true (as may well be doubted) and that there is no possible regresse of Melancholy into Choler, nor of Choler into laudable Blood : then will it inevitably follow, that all the other three juices are but only in Order to Melancholy : and that Melancholy is the principall and most perfectly concocted Aliment. Nay more, They must grant two sorts of Blood ; the one, the whole masse of blood contained in the veines, and composed of those four humours : The other, the more pure, more florid, and more spiritual part thereof, which in a stricter sense they call blood, and which some will have to be contained only in the heart and arteries, apart from the venous blood, as deputed to peculiar and more noble Uses. Now, according to this distinction, it is manifest, that not the pure arteriall blood is the nourishment of the body, but the baser, composed of diverse juices, or rather chiefly the Melancholy ; to which as to their ultimate term, or perfection the three others tend. And how incongruous it is, to conceive, that the body is nourished, either with impure juices, or with Melancholy a cold dry and earthly humour as they define it: is obvious to men of even the shallowest understandings.

3.
There are sundry parts, into whole substance the blood is not admitted.

(2) If the Blood were the Universal Aliment of the body, then certainly no part could be nourished, at which the blood doth not arrive : but we see that many parts are nourished, as the Brain, Bones, Nerves, Ligaments, Testicles,

Testicles, &c. to which notwithstanding the blood is not so brought, as to be admitted into their substance : and therefore the blood is not the Universal Nourishment. We say, so as to be admitted into their very substance ; for though blood be found in those parts, yet doth it not penetrate deeply into them, as the Nutritive juice ought to do : *alimenti enim vis* lib. de Alimen-
(saith Hippocrates) *ad ossa usque pervenit, & ossi-*
sum partes. The blood doth, indeed, touch up-
on those parts, in its running round the body ;
and but only touch them ; and for this reason,
that all the parts may be cherished and enli-
vened by the Vitall Spirits, which it carrieth
along with it. Thus, in the Brain, veins are no
where found, but disseminated upon the Mem-
branes, that are their support ; the *Plexus Cho-*
roides and some other few places excepted.
Which perhaps is the reason, why *Aristotle* 1 *Hist. an. c. 16.*
denied any blood to be contained in the brain ;
because it is not effused into the substance
thereof, as it is into the fleshy or musculous
parts.

(3) Men that are fat and plump, have but
little blood ; and such as are spare and lean,
have abundance : which could not be, if blood
were matter of nourishment. And because
Lean persons have much blood ; therefore are
they more lively, couragious, and active, as
abounding with Spirits, in proportion to their
great quantity of blood. Hence is it also, that
Lean persons bear large evacuation of blood,
without detriment of health ; because their
fleshy

4.
Fat men ge-
nerally have
the least
blood, and
Lean the most.

fleshy and musculous parts, as being firme and solid, drink up the least quantity of bloud in their pores, and so there remains the more for the fewel of the Vitall Lamp. Whereas, on the contrary, grosse and fat persons, suffer great dammage by large effusion of bloud ; because the habit of their bodies being despoyled of Spirits and hotter bloud, is filled with serous humours, and so easily degenerateth into a Cachexy. In like manner, in a grosse body, where are more parts to be nourished, there ought to be the more bloud to nourish them : but grosse men, for the most part, eat much lesse, than lean ; because they have lesse veins, and being inclined to sedentary and unactive lives, they consume but few Spirits. For it is but a small portion of the Chyle, that is, converted into the *Succus Nutritius* (the dissipation of the substance of the parts, being neither so suddain, nor great, as hath been vulgarly conceived, as we formerly explicated) and the rest, after its unprofitable parts are separated, being brought to the heart, is mostly consumed in Spirits. Such things, therefore, as relieve the Spirits, suddainly satisfie our hunger ; as good wine. Whence that Aphorism of Hippocrates ; *Famem, vini potio solvit* : because vvine revives the Spirits.

2 Sect. Aph. 36.

3.
Men perishing
by famine,
have their
arteries
and veins full
of bloud.

(4) In Animals dying of famine, and men dying of Consumptions ; good store of bloud hath been found in the veines and arteries. Which were impossible if bloud were the nourishment of the body : for, then no Animal could

could perish by famine, while it had any bloud in its vessels : nor could the body be so emaciated, in consumptions, while the veins contain so plentiful a source for the refarcition of the parts. Which reason, among others, induced Dr. Harvey, to conclude ; *etsi sanguis sit pars corporis, non tamen huic nutriendo solum destinatur. Enimvero, si huic duntaxat usui inserviret, nemo fame periret, quamdiu sanguinis quicquam in venis reliquum habetur : quemadmodum & lucernæ flammula non extinguatur, quamdiu inflammabilis olei in eâ vel minimum superpetit.* de gener. Animal exercit. 52.

(5) If the bloud were changed into Ros & Cambium, as they call them ; then, certainly, it would appear white, or inclining to whitenesse : but our sense assureth, that it is no less red and florid in those places, than in the central parts of the body. 6. The bloud continueth red and florid, in the habit of the body.

(6) Hippocrates hath a singular observation, of a certain man, a patient of his, who being much emaciated, and every day more and more consuming, notwithstanding the most restorative aliment he could take ; was at length cured, only by a very profuse eduction of bloud out of the veins of each arme, after all other means had been in vain attempted. Which would not have hapned, if the bloud were the nutriment of the parts. The reason of this admirable cure seems to be this. There is (as we have more than once declared) a twofold expence of the Chyle : one part goes to the instauration libr. 5. Epidem. t. 25. 7. Hippocrates cured a man of extream Leanness, only by profuse Phlebotomy.

stauration of the parts, as being, or constituting the *Succus Nutritius* ; the other supplies the Vitall Spirits, under the form of blood. Now when one of these exceeds, the other languishes ; and the too plentiful exhaustion of the Chyle, upon the blood being the cause of this mans Leanness, his recovery succeeded upon a turning of the streame of the Chyle upon the parts for their sufficient Nutritive juice.

8.

The blood is observed to be less unctuous and glutinous, in the Arteries, that carry it to the parts ; than in the veins, that return it from them.

(7) If the blood did nourish ; then would Fat, unctuous, and glutinous blood be most accommodate to that use : for, the serum hinders the apposition of the blood, and therefore Ichorous and weeping Ulcers are seldome consolidated. Now, the blood is observed to be more unctuous and glutinous in the veines, than in the arteries, in which it is commonly more diluted, and full of serum : but the blood is carried to the habit of the body by the arteries, and from thence brought back again by the veines. Which, certainly, is a very weighty argument, against the Blood's being the nourishment.

9.

There is a manifest Dissimilitude betwixt the blood, and sundry parts of the body.

(8) Betwixt the thing nourished, and its nutriment, there ought to be a certain Analogy, or similitude ; according to that old saying, *Partes quaslibet alimento ipsis maxime consimili enutrir* : but betwixt the blood and severall parts of the body, instead of this requisite resemblance or affinity of qualities, there is in many things a perfect Dissimilitude or disparity. For, if we compare the blood, with the brain,

brain, the Horny coat, or Humors of the Eyes, the Bones, tendons, and other the like parts, we shall find little or no proportion, or resemblance betwixt them. In an Appoplexy, where the brain is overflowed with blood effused into the substance of it, all the ideas or marks of things formerly known, are quite obliterated, nor doth any perception of them remain. Likewise when the eye is blood-shodden, the perspicuity of the coats of the eye is changed into opacity, and the transmission of the visible species through them hindered. The bones also are so many wayes discrepant from the blood, that it seems impossible they should be constituted thereof. And of the tendons, Nerves, membranes, &c. the same may be said.

(9) The Manner of Nutrition, is a certain promotion of the aliment from the state of crudity, to the state of concoction, or an Exaltation of its Spirits to a further degree of activity. And therefore, the aliment must of necessity be more crude, than the part therewith nourished. For, that promotion is not by any degradation, or Fixation of the Spirits of the aliment; but by an Exaltation or reduction of them neerer to volatility. Forasmuch therefore, as the Spirits already in the blood, are approached or advanced neerer to the state of volatility, than those contained in the parts above mentioned: certainly, the blood cannot be thought a convenient nourishment for them. The redintegration of those parts ought

10.

The progress of Nutrition, is from crudity, to fusion and volatility; not retrograde from volatility to fixation: and so the Aliment ought to be more crude, or fixed, than the parts to be nourished.

to be expected from such nutriment, as is more fixed than themselves are : Otherwise how could it suffice to the solidation or firmation of them ? But, the blood is of a more rough and grating nature, and its spirits more advanced toward volatility, than those residing in the solid parts : and in that respect is wholly unfit to nourish them. Moreover, it is necessary, the Nutritive juice should be sequestred from the blood, before it can be opportunely brought and apponed to the parts: if so, to what end was it admixt to the blood at all? shall we believe, that Nature (rather than seem idle) doth make any thing, only that she may unmake it again afterward?

II.

The blood is it self nourished, and doth consume the substance of the solid parts: and so cannot be their nourishment.

(10) What is it selfe nourished, cannot (without absurdity) be thought to be the nourishment of another: nor can that which is the cause of the exhaustion of the solid parts, be the matter of their redintegration. That the blood is it self nourished, is manifest from the large access of Chyle to it, after every meal : and that it is the cause of the exhaustion of the solid parts, is also manifest from hence, that the Vital Heat, whose *subjectum inhaesionis* is the blood, is the only consumer or depredator of the solid substance of the body. For, whatever be the effects of the Vital Heat, residing in the blood, as its proper and original subject; the very same may be justly imputed also to the Blood itself. For, albeit we sometimes ascribe the actions of things to their Qualities, or Faculties; thereby indicating the Formal

Formal Reason, or Manner ; by which the substance operateth : yet we cannot deny, but it is the very substance it self, to which those Qualities are inherent, that really performeth the action. It is the blood it self, therefore, which by reason of its inherent Heat, doth uncestantly prey upon the substance of the solid parts, and causeth them to make provision for their reparation, even after they have attained to their perfect magnitude. . Nor doth it only so, but it moreover, in case of famine, converts the solid substance of the parts into its own, supplying its defects out of their decayes. This is manifest, in long abstinence from meat, when though the habit of the body be extenuated, yet (provided the person take water, or some other thin liquor, that may be a vehicle of the Humours) do the arteries and veins continue full of blood. Thus also in Fevers, though the stomack be so weake, as to abhor all things but small beer, or cooling Juleps; yet doth the blood all that while repair it self, by colliquating the substance of the solid parts, and converting it into its own. For, how otherwise could the streams of blood be dayly replenished? And, that they are replenished, is evident from hence, that though the quantity of blood be diminished (proportionately to the strength of the patient) by Phlebotomy, in the beginning of the Fever: yet will it be again, in a day or two after, so encreased, as to require a second, and perhaps a third diminution; and that, notwithstanding the sick person hath

received little or no nourishment all that while. An undeniable argument, that the blood, in that defect of supplies from the Chyle, doth repair it self out of the spoils of the solid parts. Now, since the blood doth exhaust and depredate the solid parts; how can it consist with reason, that it should be their nourishment?

12.
The First
Matter, of
which the
parts are
made, is not
Blood; but a
certain liquid
juice, very like
the white of
an Egge.

(11) The Aliment of the parts ought to be in all things like that matter, of which they were at first composed. For, what is super-added to the parts, as they are augmented, is of similar substance with that, which was præ-existent in them, and so of necessity must be constituted *ex congenerie materia*. Now, the *Materia prima* of all the parts, is not blood, but a certain liquid juice, perfectly resembling the White of an Egg, of which the Chicken is formed; only with this difference, that in viviparous Animals that Liquor is more thin, and like the *Colliquamentum* in Eggs, after the Hen hath sitten upon them some days. For even Viviparous Animals conceive a kind of Egg in their wombs, which is involved in a thin membrane, and containeth a certain viscid humour, very like the White of Eggs, attenuated and melted by the warmth of the Hens incubation. And this Liquor is the very matter of which the Embryo is first formed: but very unlike the blood, in substance, colour, and all other qualities. As therefore the parts are not made up of blood, at first; so are they not augmented or nourished by it afterward.

We

We said, That the blood is not the *General Nutri-*
ment of all the body; thereby admitting, that it may be the *Particular* nutriment of some parts. For, as to the *Parenchymata Sanguinea*, the parts whose substance is chiefly Sanguineous; forasmuch as they seem to consist mostly of the thicker parts of blood coagulated in them, and affixt to their vessels and fibers; and that they have no Nerve derived unto them, through which the *Succus Nutritivus* might be imported into them: we conceive, that the decay of their sanguineous particles, is daily repaired by the fresh opposition and affixation of the like particles of the blood. And in this accompt, we reckon the *Liver, Spleen, Kidneys, Heart, Lungs*, and *red parts of the Muscles*. Yet in all these, whatsoever of *Fibers, Membranes, or Vessels*, is found commixt with their *Parenchyma* or Sanguineous substance; all that is to be excluded from the capacity of being nourished by the blood. But, as for all the Fibrous, Membranous, and Nervous parts of the body, and all the *Parenchymata Sanguinea*, as the Brain, Spinal Marrow, the Humours of the Eyes, Teeth, Bones, and Glandules; it is most probable (from the reasons alleadged) that they are nourished, not by the blood, but by some sweeter, softer, and milder liquor, congenerous to the spermatick matter, or *Colliquamentum*, of which they are originally constituted; which is daily brought and effused or instilled into their substance, out of the Nerve inserted into them. But of this distribution
of

13.

Nevertheless
the blood may
be the Nourishment of
such parts,
whose substance is mostly sanguineous: and what those are.

of the *Succus Nutritius*, by the *Nervus*, we shall have opportunity to discourse more particularly hereafter.

14.

The manner,
how the *Vital*
Heat is con-
served; and the
Vital Spirits
continually
recruited, ex
sanguine.

Well then, of what Use is the blood? Why truly (according to the latter opinion recited) we conceive it to serve both as the Pabulum, or Fuel of the Vital Flame, and as the Matter of which the Spirits Vital are consecreted. Concerning the manner, how Flame is maintained by its Fuel; we have already plainly, though succinctly, discoursed. And, as for the Manner *how the Vitall Spirits are continually recruited, ex Sanguine*; we may understand it to be thus. The Spirits, contained in our solid aliment, being at their first admission into the stomach, crude or in the state of *Fixation*; are soon after, partly by admission of Liquids, and partly by Fermentation, promoted, from the state of *Fixation*, to that of *Fusion*. In this state, the richer or more nutritive parts of the solid aliment, being, by way of Liquation, thoroughly commixed with the drink; there resulteth a certain milky juice, called the *Chyle*; which is a Liquor abounding with sweet, mild and delicate Spirits. Now these Spirits, so soon as they are brought to the Heart, and there commixt with the Vitall blood; are by little and little exalted to a third state, *viz.* that of *Volatility*; and so become fit subjects to entertain the Vitall Heat, and want only another recourse to the heart, to be therein, as it were by accension, advanced to the height and dignity of perfect vitall Spirits. For, the
Vital

Vitall Spirits differ from the Spirits contained in our aliment, no otherwise than in the gradual preparations and exaltations now mentioned. We are to advertise moreover, that the Heart, in its Systole, is not contracted so closely or streightly, as to expell all the blood contained in its Ventricles, at once : but leaves a good part thereof remaining in them, after the contraction is ended. And that this remaining blood doth heat and kindle the portion of blood next effused out of the veins into those ventricles ; and by that means exalt it to the condition of Vital blood. We further observe, that in the Spirits of the blood, there are sundry degrees of volatility ; so that some attain to the highest degree of volatility much sooner, than others ; and none, untill they have undergone severall Circulations, and as many fresh Accensions in the Heart. For, in every Circulation they grow more and more subtile and agile ; and so must at length be brought to the requisite height of volatility. To which having once attained, in the very next Circulation (though they are restrained and kept in, by the sides of the heart, and coats of the arteries, while they remain therein) being diffused upon the outward parts of the body, as they warm and vivify those parts, so do they soon flye away, and disperie themselves into air. And while these thus flye away, other Spirits lesse volatile are, by the colder temperament of the parts, by which they pass, somewhat repressed : so that the force of their expansive

panfive motion is much abated, the Mication or panting of the bloud interrupted, and the bloud wherein they are, of Arterial, or vital bloud, is made venouse or Natural; and such it continueth, untill the next circulation bring it again to the heart, there to be kindled afresh, and exalted to the due heat of vitality. Which once acquired, it recovers its intermitted motion of Mication, or rising and falling alternately, and yeeldeth a fresh supply of spirits vital; which being transmitted to the habit of the body, are soon dispersed, like the former.

15.

The Reason of
the *Mication*,
or panting
motion of the
Blood, in the
arteries.

And thus is the vital Flame kept alive, at no lesse expence, than a continual dissipation of the most votatile spirits of the blood. For, that vital Heat ariseth from within, and the most subtile spirits are the first Movers to the excitement thereof: the motion by which they do it, being their indeavour to expand themselves, and to dilate their bounds, while the other grosser elements, or ingredients of the bloud, oppose them therein. And this *Strife*, or *Counter-activity* of the spirits, on one part, and of the grosser ingredients of the blood, on the other, doth exhibite the *general Essence of Heat*. To which may be added this short observation, that in this Contention, one while the spirits prevailing, do lift up, or swell the mass of bloud; another while the grosser elements (the contraction of the Heart and arteries assisting them) prevailing, countermand and interrupt that expansive motion: and that by
this

this alternate conquest of these Antagonists, is made the *Mication* or *Rising and Falling* of the blood, the one in the Dilatation, the other in the Contraction of the Heart and arteries. Forasmuch, therefore, as the vital Heat doth consist in the rarefactive motion of the spirits, and the renitence of the grosser parts of the blood; and that the spirits, for the most part, at least alternately, obtain the victory and dominion over their opponents: it seems most consentaneous to truth, that *this vital Heat cannot be preserved, without a perpetual expence of the most pure, i. e. the most volatile spirits of the blood*; and consequently necessary, that during life, *fresh spirits must be perpetually minted out of the blood*, to defray that vast and continual expence. And this we conceive to be the true progress of Nature, from the first reception of the spirits contained in the Aliment, to their eduction into the Chyle, their sublimation in the heart, their gradual exaltation to the highest degree of volatility, and lastly their dissipation through the skin into aer: upon which depends the Conservation of the vital Heat, and the continual Generation of the vital Spirits.

OF THE MOTION OF THE BLOOD ; ITS CONDITIONS AND CAUSES.

Exercitation the Sixth.

Of the Motion of the Blood, its Conditions and Causes.

I.
The Method
of the Chap-
ter.

Nature (which in all her works, hath the End, and Means conducing to that End, alwayes closely connected in one idea) having ordained the perpetual generation of this vital Nectar, the Blood, in Animals, for the Uses, in the precedent Chapter recited : that she might not be deficient in the means requisite to fulfill those Uses, hath also ordained, that the blood should be carried from the Fountain to all the parts, in living streams, by a certain admirable *Motion*, necessary to its distribution through the whole body. Now, that we may fully understand the nature of this Motion, we are to consider (1) the *Manner* ; (2) the *Conditions* ; (3) the *Causes* of it.

2.
That the Mo-
tion of the
blood is Cir-
cular ;

Concerning the FIRST ; we observe, that the blood is continually carried, or rather driven from its fountain, the Heart, in the centre of the body, by the Arteries, to the circumference ; and back again from the circumference, to the centre, by the veins, irrigating, cherishing, and vivifying all the parts, as it passeth along : and that therefore, this Motion was, by the

the glorious Inventer of it, *Dr. Harvey*, called the *Circulation* of the blood ; *quòd*,

Ejus enim semper redeat labor actus in orbem.

For, in the first place, the blood is effused out of the vena Cava, into the right ventricle of the Heart ; as may be evidently seen in living Animals dissected, especially in Coneys. For, if the trunk of the vena Cava be bound with a ligature, both above and below the heart ; you may perceive all the blood contained in the space betwixt the ligatures, to be speedily discharged into the right ventricle of the heart, to which the vena Cava is conjoyned.

From the right ventricle of the heart, it is (the heart contracting it self) expelled into the vena arteriosa, and so into the Lungs ; but not through the septum transversum, or middle partition of the heart, as some have imagined, conceiving the same to have some certain obscure passages from the right into the left ventricle ; only because they could, without much violence, thrust a style, or probe through it : when, indeed, those passages are not made by Nature, but by the point of the probe ; the flesh of the heart being so tender, as that it is easily penetrated, by any hard and pointed instrument though but gently intruded.

Passing through the vena arteriosa into the very substance of the Lungs ; the blood is immediately returned into the venosa arteria, and through that into the Left ventricle of the Heart.

3.

From the Vena Cava, into the right Ventricle of the heart.

4.

From the right Ventricle, by the Vena arteriosa, into the Lungs :

5.

From the Lungs, through the Arteria Venosa, into the left Ventricle;

Heart. This is demonstrable thus. Having made a ligature upon the great branch of the *Arteria venosa*, neer the pericardium, in the lungs of an Animal yet living; you may observe that branch to be soon filled and much distended with blood, in that part, which is toward the lungs, and that emptied and flaccid, that is next the heart: and upon remove of the ligature, the blood will flow again from the lungs to the left ventricle. Now, there being no other way, by which this blood can flow to the left ventricle, but from the lungs: it must of necessity descend thence, by the *Arteria venosa*.

6.
From the left
ventricle, into
the great
Artery, and
thence into
the smaller
Arteries.

The left ventricle having thus taken in a quantity of blood, answerable to its capacity; the heart instantly contracting it self, expelleth the same (at least, good part thereof) into the Great Artery (arising from the left ventricle) thence into the lesser arteries, and so into the substance of the flesh; from whence the blood is intruded into the capillary veins, by them into the greater veins, from them into the vena Cava, and at length into the right ventricle of the heart, there to begin the same circular progress again.

7.
From the
smallest Arteries, through
the substance
of the flesh,
into the smallest
veins.

We say, from the capillary arteries into the *substance of the Flesh*. For, as to those, who will have the blood to pass out of the small arteries, into the small veins, *per Anastomoses*, by certain inosculations, or open passages from those into these: we challenge them to demonstrate to the sense, any such way of intercourse

or communication betwixt arteries and veins, in the whole habit of the body; and Dr. Harvey did the same before us, when He said, *De Anastomosi Venarum & arteriarum, ubi sit, & quomodo sit, & qua de causa, neminem hactenus recte quicquam dixisse, suspicari licet.* And why may not the blood be as wel conceived, to permeate through the pores of the flesh, as water through the pores of the earth, the sweat through the skin, the serum through the parenchyma of the Kidneys, or as the same blood through the thick substance of the Liver.

de mot. cord. & sang. cap. 9.

Nor is only that bloud brought back to the heart, by the vena Cava, which passed through it before; but the stream is augmented by the accessse of fresh Chyle also, imported into the subclavian branches of the same vena Cava, and thence into the right ventricle of the heart. For, this is not only easie to be done, in respect of the vicinity of the ascendent and descendent trunck of the vena cava, to the right ventricle; but also necessary, there being no other way for the new supply of bloud to passe; and that it is done, this experiment doth testifie. The vena cava being bound both above and below the heart; all the bloud contained betwixt the two ligatures, will in a very short space be discharged into the right ventricle.

8.

How the New-made blood is circulated with old.

Again, the Heart seems to immit more bloud into the Great Artery, in the space of one hour, than the proportion of Chyle can amount to, in several dayes. For, in most men, the Heart makes more than 3000. pulses, in an hour;

9.

That more blood passeth through the heart, in an hour, than can be supplied from the chyle, in several dayes.

hour ; and at every systole it expells some bloud out of its left ventricle into the Aorta ; as may be sensibly demonstrated by this , that upon a ligation of the Aorta , neer the heart, and an incision made betwixt the ligature and the heart , you may observe some quantity of blood (more or lesse) to be squirted forth by the incision, at every systole , unlesse the heart be grown weak and languid ; and yet even in that case , some quantity of bloud will issue forth at the hole, once in 3 or 4 pulses. Nay, when the cone or point of the heart is cut off, and the heart held upright ; though the ventricles be not then full , yet will some blood be squeezed out of them, every time the heart contracts it self, and that to the distance of 3 or 4 feet, as *Dr. Harvey* observeth.

2 cap. de. mot.
cord. & san-
guin.

10.

The Necessi-
ty of the Cir-
culation in-
ferred from
three conside-
rations, viz.

As for the *Quantity* of blood admitted into the ventricles of the heart, when it is dilated, and expelled into the Great Artery, when it is again contracted ; it cannot be precisely determined. For, if in the same individual person, the motion of the heart, being sometimes more strong and swift, and sometimes more weak and slow, doth make the Circulation of the blood more swift, or more slow proportionately : certainly in the species, it must be impossible to commensurate the quantity of blood passing through the heart, at every pulse ; since there is great variety among men, in respect of their different temperaments, ages, sexes, diet, exercises, passions, and the like, all which vary the pulse, and consequently the motion of the blood.

blood. However, that some satisfaction may be given to enquirers herein, we are to consider Three things, viz. (1) *How much blood may be contained in the heart of a Man, in its Diastole ;* (2) *How much may be expelled out of it, in its Systole ;* (3) *and How many Pulses, or Diastole's and Systoles, the heart doth commonly, in healthy and temperate men, make in an hour.*

Concerning the *First* ; there are different observations. *Harvey* saith, that in a mans heart dilated, he found more than two ounces of blood. *Plempius* affirms, that he found almost two ounces. *Riolan* will allow scarce half an ounce, in the left ventricle ; but somewhat more in the right. And *Hogeland* comes much lower, admitting only one dragme. But, all men generally grant, that the whole masse of blood contained in the body, doth seldom exceed 24 pounds, or pints, and as seldom come short of 15.

Concerning, the *Second* ; we say, that in every systole is expelled either the fourth or fifth or sixth, or at least the eighth part of the blood received into the heart, at the precedent Diastole. *Harvey* supposeth at least one dragme, and proves that his supposition from the sudden effusion of all the mass of blood, if but the least artery be cut : and because all the blood may be transmitted through the heart, in the space of half an hour, He thereupon concludes for certain, that much blood is expelled into the great Artery, at every systole. *Conringius* also makes the same compute. *Walæus* and *Sleyelius*

the quantity
of blood con-
tained in the
heart, in its
Diastole ;

the quantity
expelled out
of it, in its
Systole.

Of the Motion of the Blood;

Sleyelius admit half an ounce : but compute only from one scruple. *Hogeland* acquiesceth in one dragme. And *Thom. Bartholinus* brings it down to only half a scruple. But they all agree, that in the contraction of the heart, the sides of the ventricles are not drawn so close together, as to expell all the blood contained in them.

The Number
of Pulses, in
the space of
an hour.

Concerning the *Third*, we remember, that *Primrose* reckons 700. pulses in an hour; *Riolan* 2000; *Waleus* and *Regius* 3000. *Cardan* 4000; *Plempius* 4450; *Sleyelius* 4876; *Bartholinus* 4400, or thereabouts; and *Harvey* about 2000; each one numbering the pulses in his own wrist.

Now, from these three things premised we may collect how much blood may be expelled out of the left ventricle of the heart, into the Aorta, in the space of one hour, according to the several numerations of pulses viz.

From	3000	times repeated there arise	lb 10	35	} Of blood passing thorough the heart into the arteries, in one hour.
	4000		lb 13	310 35	
	4450		lb 15	33 35	
	4400		lb 7	37 35	
	2000		lb 20	10	
	2000		lb 41	8	
	2000		lb 83	4	
	2000		lb 166	8	

Again, setting it down for a ground, that the quantity of blood contained in the whole body, doth amount only to lb 15. (for that is according to the most modest accompt) and allowing

lowing some part thereof to be consumed by the Lamp of life, and as much to be supplied out of the Chyle: we may inferre these 4 necessary Conclusions.

(1) That more blood is transmitted through the heart, once in every hour, than can be supplied out of the Chyle, in many hours.

(2) That all the blood in the body is transmitted through the heart, once in a quarter, or half, or a whole hour, or in two hours at most.

(3) That so much is not required to the conservation of the vital Flame, and the confection of vital spirits.

(4) That, since the vessells are not broken, that the blood cannot return back out of the heart, nor be any wayes dissipated: it is absolutely necessary, that the blood must return to the heart again by the veins, or be Circulated perpetually, as the immortall *Dr. Harvey* hath demonstrated.

Nor is this Circulation of the blood only Particular to some Arteries and Veins (as some have inconsiderately imagined) but *Universal*, or common to them all, throughout the whole body. For though it be, indeed, more demonstrable to the sense in the Limbs, where the vessells being ample and conspicuous, admit of ligatures more conveniently, than those in the Inwards: yet doth observation teach us, that the motion of the blood is the very same in the very *Entralls* also. In particular (that we may deduce it through the most conspicuous Arteries

II.
That the Circulation is Universal, in all the Arteries and veins of the whole body.

ries and veins of other interior parts , besides those already mentioned) the blood is carried in the

Testicles , by the spermatick Arteries : from them, by the spermatick veins, into the left Emulgent and vena Cava.

Intestines, by the Mesenterick Arteries : from them , by the Mesenterick veins, into the *Ramus Mesentericus*, and thence into the vena Portæ.

Spleen, by the left Celiacal Artery : from it, by the *Ramus splenicus* , into the vena Portæ, and thence directly into the Liver.

Abdomen,
to the

Stomack and Omentum, by other branches of the Celiacal Artery : from them , by the Gastrick and Epiploical veins , into the *Ramus splenicus*; thence into the vena Portæ, and so to the Liver.

Kidneys, by the Emulgent Arteries : from them, by the Emulgent veins, into the vena cava.

Outside of the Heart , by the Coronary Artery : back again, by the Coronary vein , into the vena Cava.

Thorax, to
the

Pleura, by the Intercoastal Arteries : from it , by the veins thereof , into the vena Azygos, and thence into the vena Cava.

Head,

Head to the Membranes of the Braine, by the Carotides and Neck-Arteries (which tend to the four Cells of the brain, but are not therein terminated, as some Anatomists have thought): from them, by the jugular veins, into the ascendent trunk of the *VENA CAVA*.

All which is discoverable to the sense, by binding those vessels, in Animals cut up alive. For, the swelling, caused in either vein or Arterie, by the flux of blood there arrested, will alwayes appear on that side the ligature, from whence the blood flowes.

Here we are to advertise, that in the *Fœtus*, or Infant-unborn, the manner of the Circulation of the blood, through the vessels of the Heart, is different from that we have described. For the blood is not carried from the Mothers womb, into the Umbilical Arteries; but from the *Placenta Uterina* (in which those Arteries are terminated) into the Umbilical vein: which conducteth it along to the Liver of the *Fœtus*, from whence it is transmitted by the *Vena Cava* into the right Ventricle of the heart. Being brought thither, it is transferred into the *Vena Arteriosa*: but, because the Lungs are not yet moved, as after the birth, in respiration; and so their vessels are not dilated and contracted alternately, and consequently they can neither receive the blood

I 2.

But, after a peculiar manner in an Infant unborn.

out of the Vena Arteriosa, nor impell it into the Arteria Venosa: therefore hath the providence of Nature contrived and framed Two peculiar passages, the one a conduit or pipe, conveying the blood from the Vena Arteriosa, into the Great Arterie; the other a certain foramen, hole, or inlett, by which the blood passeth from the Vena Cava into the Arteria Venosa, thence into the left Ear of the heart, and so down into the left Ventricle. From thence (as well as that from the Vena Arteriosa) it is infused into the Great Arterie. So that in an unborn Infant, Nature useth the two Ventricles of the heart, as if they were but one: and this, lest the infant should have his Blood too hot and adust, while he wants the ventilation of the air, and expulsion of fuliginous exhalations, through the Lungs. From the Great Arterie, the blood is sent into the Umbilical Arteries, which return it to the *Placenta Uterina*; where permeating the substance thereof, it is again infused into the small branches or (rather) roots of the Umbilical vein, by them into the trunk, and at length into the Liver, Vena Cava, and Heart, as before.

13.
This Motion
of the blood, is

Continual;

Having thus explained, by what wayes the blood is moved in a round; it follows, that we consider the *CONDITIONS* of that its motion. Concerning which, we observe that the Circulation of the blood is,

(1) *Continuall*. For, since the Heart is continually in motion, and takes in blood, in its
Diastole

Diastole, and dischargeth the same again, in its Systole, never intermitting that its proper action, but in great swooning fits, or in the very article of death: it is necessary, that the motion of the blood be likewise continual.

(2) *Vehement*; as may be inferred from the hardness and distension of an arterie, or vein bound with a ligature. For, nothing can be distended to great hardness, by a thin and liquid matter, especially upward, unless that matter be with vehemence impelled into, and retained in it. But, this vehemence of the motion is greatest near the heart, and is afterward diminished by degrees, according to the severall degrees of distance from the heart; so that the extream arteries have but little pulse, unless it happens, that the impellent force of the heart be encreased, as in Fevers, Inflammations, Violent exercise, some passions, &c. Which is also the reason, why the veins have no pulse, the impulse of the blood being less in them, than in the smallest arteries.

(3) *Swift*. For, an artery or vein being compressed by ligature, will swell up and be distended, as it were in a moment; and the blood may be observed to flow in its course very swiftly, so soon as the ligature is removed. But how swiftly, is not easily determined; there being so great variety of Causes, Natural, Non-naturall, and Preternatural, that accelerate or retard the flux of the blood: only thus may be inferred from the precedent compute of the number

14.
vehement;

15.
swift;

number of Pulses, and the quantity of blood expelled out of the left ventricle of the heart, in every systole, That the whole mass of blood doth pass through the heart once in an hour or two, at most. Yet is not the current of blood neer so swift in its channels, while they are whole, as when one of them (vein or artery) is cut : because in that case, the blood streams forth into the free and easily-yielding aer, without any resistance ; but being confined in its vessels, it is forced to distend them, and drive on the foregoing current.

16.
Of equall velocity in the Arteries and veins.

(4) *As swift in the Veines, as in the Arteries.* For, though the impulse be more vehement in the arteries, as being continued to the heart, than in the veins ; and therefore it might seem reasonable, at first consideration, that the motion should be proportionately more swift in the arteries : yet, considering, that the Arteries are still smaller and smaller toward their extremities, & that the flux of the blood must needs be more and more retarded, as it approacheth those extremities ; and on the contrary, that the veins grow wider and wider, from their extremities, to the centre of the body, and so the blood hath still larger and larger spaces to run through, in its return to the heart ; we may safely conclude (conjecturally) that the velocity of the motion is as great in the veins, as in the arteries. This is also confirmed by sense ; for, the Vena Cava, in all that tract from the Liver, to the subclavian division, may be observed to beat, as often as the
Great

Great Artery ; and so must import blood into the right Ventricle, as fast as the *Aorta* doth export it from the left. Which doubtless is the reason, why the *Vena Cava* hath fleshy Fibres upon it, when it approacheth the heart. Nevertheless, we conceive the motion to be swifter in the Arteries, when the heart contracting it self, doth impell the blood into and through them; than when, dilating it self again, it doth intermit that its impulse. Which is true likewise of the blood in the veins, as may be sometimes observed in *Phlebotomy*, when the ligature is not so streight, as to cause much distension of the vein, in which the incision is made: for, in that case, the blood wil flow forth more swiftly, every time the heart is contracted. And these are the *Conditions* of this admirable motion of the blood.

Lastly, concerning the *CAUSE* of this motion ; it is necessary that the blood be moved either by it self, or by some other principle: and if it be the Author of its own motion, then that must be in respect of either an inherent motive-Faculty, or of its Ebullition, or of its Rarefaction, or of its Quantity, whereby the Ventricles of the heart are distended, and so irritated as to discharge the same, by contracting themselves. If the motion be derived from an External principle ; then it must be referred either to Attraction, or to Vection, or to Pulsion. Let us, therefore, see which of all these may be the most likely cause of the Motion of the blood.

First,

17.

The blood, nor
the cause of its
own motion,
in respect of
any motive
Faculty, inhe-
rent in it.

First, That the blood is not the cause of its own Motion, *ratione insitæ sibi Facultatis*, by reason of any inherent Faculty; may be inferred from hence, that in blood effused out of its vessels into the body, or any other receiver, no motion at all can be observed: and it is hard to conceive, that it should be so corrupted in a moment, as wholly to lose a faculty essential to it. *Dr. Harvey*, we confess, affirmeth, that he observed a certain obscure motion of the blood, in the right ear of the Heart (where He supposeth the motion of the Heart first to begin, and last to end) after the Ear had ceased to move; but we refer that to the Mication of the blood from the Vital Spirits not yet wholly extinguished.

18.

Nor, in re-
spect of its
Ebullition.

Secondly, That it is not the Author of its own motion, *ratione Ebullitionis* (which *Arist.* calls *ὕψωσις*) is manifest from these subsequent reasons. (1) No Ebullition can be constantly equall, or of the same tenour: but the Pulse of the heart, and so the motion of the blood, is, in temperate and healthy men, for the most part equall. (2) As the Ebullition is greater, so would the pulse; but in burning Fevers, the Ebullition is extream great, by reason of the great intension of the heat; and yet the pulse is frequently small, and weak; as also in the beginning of putrid Fevers, as *Galen* long since remarked. (3) The blood suffers no ebullition, as it passeth through the heart. For, if in the dissection of a living Animal, you make an incision either into the left Ventricle of the heart,

heart, or into the Great Artery neer it ; you shall perceive the blood flowing out at the hole, to be pure and such as before it came in- to the heart, not frothy, boyling, or rarefied; and to continue such as at its first efflux: yea, more, if you receive the blood issuing from an incision of the *Vena Cava* , in one sawcer, and that issuing from the left Ventricle, in another; you shall not be able to discern any difference betwixt the one and the other, either soon, or a good while after. An invincible argument against the Ebullition of the blood, first imagined by *Aristotle*, and since defended by many great men, his sectators. (4) The plunging an arme or legg into cold water, would suppress the Ebullition, and consequently the motion of the blood. For , if you apply a close ligature to a mans arme, and then immerge the same into cold water, or Snow ; upon solution of the ligature, he shall find the blood returning to his heart, with so great a sense of cold, as very much to offend him. Which cold arising to the blood, from its being long detained in the extremities of the arme bound ; *Dr. Harvey* will have to be the cause of swooning immediately after blood-letting, in many men; the heart receiving injury from that acquired cold.

Thirdly, Not *ratione Rarefactionis* ; because (1) in living dissections , where the heart yet continueth its motion, no man ever hath, or can observe any such thing as rarefied blood to flow from either the left ventricle, or the

19.
Nor of its
Rarefaction.

M

Great

Great Artery, if cut ; but pure and such as is from the Ears let down into the ventricles.

(2) The Heart it self, when cut in pieces, or wounded, may be observed to beat ; yet not from any rarefaction of the blood, for then it hath no blood in either of its Ventricles, or Ears. (3) It hath been observed in Doggs,

that after the point of the heart hath been cut off, and the remainder turn'd upside down, though the ventricles could not be halfe full, the blood hath yet been squirted forth at the top, even to the distance of three or four feet ; which were impossible, in case the rarefaction of the blood were the cause of its motion.

(4) The musculous flesh of the heart, is more firme and strong, than to be subject to inflation and detumescence, meerly from the rarefaction of the blood. It must be a more forcible Agent, that moves that great and weighty machine of the heart. (5) If the blood were so much rarefied in the Ventricles, then certainly ought the orifices of the Vena Arteriosa, and Aorta, to have been much larger, because the blood would have required more room for its egress, than for its ingress. (6) The

motion of the heart, and of its valves would be confused ; for the Diastole of this, and opening of them, would happen at the same time, and consequently the valves would become useles ; both which are repugnant to experience. Besides, the opening and shutting of the valves would be co-incident with the Systole of the Great Artery. (7) That the blood.

blood should be rarefied in the heart, and in a moment again refrigerated in the arteries ; is contrary both to sense and reason : and if the rarefaction should so soon cease ; why is it at all ?

It remains, therefore, that if the blood be the efficient of its own motion, it must be so only *ratione Quantitatis*, by reason of its quantity filling and distending the Ventricles of the heart, and irritating them to discharge it, by contracting or shutting themselves. For, the heart being as it were burdened with the blood distending its cavities, doth contract its Fibers and so its Ventricles, to vindicate it self from that oppression ; no otherwise than the stomach, guts, bladder, womb, &c. which being extended by meat, chyle, wind, urine, and the infant, drive themselves together, by the help of their Fibers, and so exclude that was burdensome to them. And thus is it probable, that the Heart is continually moved by the blood, like a Mill perpetually agitated by a stream of water ; which stream being cut off, the motion instantly ceaseth. This may be credited upon the force of this one experiment ; if the *Vena Cava* be intercepted by a ligature, so soon as the heart hath disburdened it self of what blood it hath received from thence, it instantly remitteth its motion ; and upon letting in the stream again, by removing the ligature, it as suddenly recovers it. Than which there cannot be a more convincing argument, that the quantity of the blood flow-

21.

But of its Quantity distending the Ventricles of the heart.

ing into the ventricles, is a cause of the motion of the heart, and so of its own motion.

21.
Th. blood not
moved by
Attraction;

We say, *A Cause*; not the only cause: for we shall soon find another efficient as necessary and immediate, to the motion, as the blood in the respect mentioned.

*Apolog. pro cir-
cular. sang. ad-
vers. Parisan.
pag. 27. ad 49.*

That nothing doth *Attract* the blood either to or from the heart, is evident from hence; that in Nature there is no such thing, as the motion of a body by attraction; as hath been by solid and irrefutable arguments proved by that heroical wit, and most accomplish't Scholar, *Dr. Ent*; and also by our selves, in the beginning of our discourse of *Occult Qualities*, whither (for expedition sake) we referr the unsatisfied.

22.
Nor by
Vestion;

Nor is it moved, *per modum Vestionis*, by way of Carriage. For, nothing can be imagined to carry along the blood in its course, but the spirits; and those would, in respect of their Levity, carry it only upward: but we see that the blood is moved also downward, and *ad latera*.

23.
But by *Impul-
sion* of the
heart, endow-
ed with a Pul-
sifick Faculty.

It remains, therefore, that the blood is moved in round, *per modum Pulsionis*, by *impulsion*, or *protrusion*: and the Impellent can be no other, but the *Heart* contracting it self, and so expelling the blood contained in its ventricles into the Great Artery, from whence it is urged, or pressed forwards into the smaller arteries, by the succeeding current. We conceive, therefore, that the Heart is endowed with a certain Motive-virtue inhærent and essentiall, called the *Pulsifick Faculty*, which is conjoyned,

conjoynd, as a concomitant cause, with the blood it self, in giving it a due motion: whether it be, that this Faculty doth regulate the influx and efflux of the blood, which would otherwise be irregular; or that of it self it produceth the motion, which cannot be afterward continued, in case the flux of the blood be once interrupted. That this Faculty is necessary, may be inferred from these *Reasons*.

(1) As the Pulse, so the influx of the blood would be alwayes unequall, unless it were regulated by a Faculty. (2) When the blood is moved vehemently in Fevers, by the intense heat agitating and urging it; and in men at the point of death, *propter extremos naturæ conatus*, by reason of Natures agony and last efforts: yet is the pulse more weak and low, than at other times, because the Pulsifick Faculty is either much oppress'd, or much weakned. On the other side, though the Faculty continue strong, yet is the influx of the blood much diminished, after large hæmorrhages, or upon great obstructions of the capillary arteries and veins, in the habit of the body. Which consideration seems to us sufficient to import the necessity of conjoyning a Pulsifick Faculty, with the quantity of the blood distending and so molesting the Heart, as a *double proxime cause* of the bloods motion.

(3) Though the heart be cut in pieces, yet will each piece have a kind of weak pulsation, as long as it continues warme; which in all probability is to be ascribed to the Faculty implanted

planted in all its Fibres , and not yet utterly destroyed.

(4) It would be derogatory to the majesty of that Prince of all the parts, the Heart, to be moved by the violent impulse of an external principle, and it self conduce nothing thereunto.

Notwithstanding these reasons alleaged, we dare not set up our rest in this doctrine of the Ancients , concerning a Pulsifick Faculty implanted in the heart : only we have recited it, as the most probable Conjecture of all others, touching this abstruse Argument, the proxime Cause of the Motion of the blood. Nor shall we adhere to it longer, than untill we shall be so happy as to meet with a more satisfactory solution of that admirable Phænomenon. In the mean time , Modesty commands us to declare, that we find this Knot to be too hard and intricate for the teeth of our weak understanding. And well may we make this acknowledgment, when the subtle *Frucastorius* , after a long scrutiny into the same subject , was at length forced to desist, with *Motum cordis soli Deo cognitum esse opinor* ; and that even *Harvey* himself professeth, that He found it *rem arduam & difficultatibus plenam*. We remember the modest sayings of two great Men, upon the like difficulties ; the one of *Galen* , *Quo pacto hæc fiat, si scrutaberis; convinceris te non intelligere neque tuam imbecillitatem, neque Opificis tui potentiam* : the other of *Scaliger* , *Quandam humanæ sapientiæ partem esse, quædam æquo animo nescire velle* ;

velle ; & veram sapientiam , nolle nimium sapere.
And we think, we need say no more, in excuse of this our professed ignorance.

Besides this Two-fold Proxime Cause, there is also another Remote one , viz. the Peculiar Conformation , or Fabrique, of the Heart and its vessels. And among all the parts in this curiously framed Machine of the heart, those which are most official or instrumental to the motion , are the *Fibers* and *fleshy columnes* ; which serve not so much to the strength of the heart, as to the motion of it. For, in the Systole, all the Fibers, both small and great, as well those in the inside of the ventricles , as those in the Septum, or partition-wall betwixt them (like an artificial network made in the forme of a purse) being contracted , or drawn together ; the blood contained in the ventricles, must necessarily be expelled or pressed out of them.

24.

The Fabrique of the heart, a remote cause of the motion of the blood.

The Motion of the heart , which is called the *Pulse*, as being continual, and made partly by the influx of the blood, partly by the Pulsifick Faculty residing in the heart it self ; doth consist of 3 things, the *Systole* , the *Diastole*, and the *Perisystole* : all which are to be explained by their proper Causes , according as ocular Inspection, and Reason doth dictate them to the understanding.

25.

The Motion of the Heart described ; as consisting of two contrary motions, and a Respite betwixt them.

(1) The *Systole* , being the proper and natural motion of the heart , is the Contraction or drawing together of the heart to a narrower compass , that so the blood contained in the right ventricle may be expelled through the vena

vena arteriosa into the Lungs; and that contained in the left, may be expelled into the Great Artery, and so into all parts of the body.

(2) The *Diastole*, being a motion only Accidental to the heart, is a Dilatation, or opening of the heart, that the blood may flow into the right ventricle, out of the vena Cava; and into the left, out of the Arteria Venosa.

(3) The *Perisystole*, is a certain quiet or short respite betwixt the Contraction and Dilatation of the heart, during the small time, that the blood is entering into, or issuing out of the ventricles. In healthy men, this pause is so short, as not to be distinguished from either of the two contrary motions: but sufficiently manifest in men at the point of death. It is also *double*, there being one respite betwixt the Systole and Diastole; and another betwixt the Diastole and Systole. And this is the natural state of the Heart.

26.
And the Figure of it in each.

As to the *Figure*, or *Forme* of the heart in those contrary motions; from the dissection of Animals alive, from the commodity of its motion and quiet, and from the position of its Fibers and other parts, we have learned it to be thus.

In the *Systole*, it may be observed that (1) the point of the heart is drawn upward toward the Basis of it, in order to the expulsion of the blood; the length of it being diminished, and breadth proportionately encreased: because the basis is immoveable, in respect of the cone,
which

which is fastned neither to, nor by any vessells.

(2) The *inner* walls, or sides toward the ribbs, are brought neerer each to other; because they are constringed and made narrower; as may be perceived by putting a finger into either of the ventricles, at the time of their contraction: but the *outward*, becoming tumid, seem to be enlarged in latitude, from the contraction of all parts inflated in the tension or stretching.

(3) The fore part of the heart is lifted up towards the sternum, and chiefly neer the base; for, where the pulse is felt, there doth the heart strike the breast with its base, that part being lifted up, and brought neer to the sternon: and at the same time (not in the Diastole) is the heart vigorated, and the arteries dilated and filled, and the pulses are felt both in the breast and wrist, the Diastole of the Arteries being coincident with the Systole of the heart. But the Pulse is more plainly felt in the left side, because there is the origine and orifice of the Aorta. (4) The whole heart becomes tense and hard, and contracted to a smaller bulk; as is manifest both to the sight, and to the touch. (5) The heart appears white, especially in imperfect Animals, such as Serpents, Frogs, Eeles, &c. by reason of the expulsion of the blood in the Systole.

In the *Perisystole*, when the heart is soft, lax, and in its proper state, (1) the cone recedeth from the base; and in some Animals, the base also recedeth from the cone: (2) The lateral parts, both the interior and exterior, are

N

extended

tended toward the ribbs : (3) The anterior face of the heart sinks down, and the posterior is depressed, especially neer the orifice of the great Artery.

In the *Diaſtole*, which begins in the middle of the Dilatation, and ends in the middle of the Contraction. (1) the upper ſide is lifted up and diſtended by the blood falling into the ventricles out of the Vena cava, and Arteria venoſa; the ſwelling ſenſibly beginning at the baſe, and progreſſing to the cone. But the baſe doth not then ſtrike the breaſt, becauſe the Arteries at that inſtant are contracted, and the heart ceaſeth from expulſion of the blood. (2) The heart is flaccid and ſoft, becauſe it is then only paſſive, in receiving the blood. (3) The ſides become extenſe, and the cavities enlarged, and therefore if you put your finger into the heart, during the *Diaſtole*, you ſhall perceive no conſtriction, as in the *Syſtole*. (4) The heart appears red, becauſe of the tenuity of its walls, and their repletion with blood. (5) The Cone receding from the baſe, makes the heart longer, that it may be more capable of blood. And thus doth the heart vary its Figure, in each of theſe three poſitions.

OF THE DEPURATION OF THE BLOOD.

Exercitation the Seventh.

Of the Depuration of the BLOOD.

FROM the Circulation of the blood, we (as Nature) advance to the *DEPURATION* or Defecation of it, from its unprofitable or excrementitious parts. And here we are to consider (1) the *Generation*, (2) The severall sorts of Excrements generated in and to be separated from the blood, (3) The *parts* in which, and (4) The *Manner how* they are separated.

Concerning the *FIRST*, we observe, that the blood being a heterogeneous liquor, consisting of various Elements or material principles (as the Element of which it is generated) and so not capable to be wholly changed into either the fuel of the Vital Heat; or Vital Spirits: when those parts of it, which had their Spirits less closely and firmly united to their grosser Elements, or (which is the same thing) which were most prone to volatility,

I.
The Genealogy of the Excrements.

are consumed and dispersed ; it cannot be, but that the remains or reliques thereof must thenceforth become not only useless, but also incommodious to Nature, and therefore as soon as may be, to be rejected. For the sweet and inflammable Spirits of the blood being exhausted ; to what use can the remaining mass serve ? It can be no longer the subject or residence of the Vitall Heat, for the conservation whereof the blood is principally made : nay, if retained in the body, it would rather damne and destroy the same noble principle, the Vital Heat. For, the *Sulphur* contained in the blood, doth by reason of the continuall mication and indeavour of the Spirits to fly away and disperse themselves, and of the decocting activity of the Vitall Heat exercised upon it, become adust, and contract a manifest bitterness and acrimony ; and the *Caput mortuum*, or Terrene and grosser part, conjoynd with the Fixative Salt, is apt to coagulate and to be petrified ; and the *Phlegma*, or insipid and viscid part is apt to obstruct the capillary arteries and veins, and so impede the Circulation ; and lastly, the *Aqueous* part, or potulent matter, as being apt to render the blood too dilute and serous, is wholly unprofitable. These parts, therefore, being no longer usefull ingredients of the blood, degenerate into Excrements ; and ought to be sequestred from it.

This Generation of the Excrements of the blood, may be appositely adumbrated by the
Exam-

Example of Wine distilled. For, as Wine is a Liquor consisting *ex Elementis primicerviis*, of Various choyce ingredients, or dissimilar parts: so is the blood. As the Spirits or more fugitive parts of Wine, are easily separable from the more fixed, *viz.* the Phlegme, Tartar, crass Sulphur, &c. by heat: so are the Spirits of the blood easily separated from the more fixed parts of it, *viz.* the Phlegme, Salt Tartar, crass Sulphur adust, the Aqueous or potulent matter, by the activity of the Vital Heat. As the Spirits of Wine are, by repeated destillations, advanced to that height of Volatility or subtility, as that some of them flye away and are dispersed into air, in every rectification: so likewise are the Spirits of the blood, by repeated Circulations through the heart, brought to that degree of subtility and volatility, as that they cannot be longer contained or imprisoned in the body of an Animal, but penetrating through the pores, are exhaled by way of dry sweat, or insensible transpiration. And as the residue of the Wine, after the Spirits are gone, remains a dead mass, or vappa, consisting only of a Phlegme, Tartar, and crass Sulphur (which by long heat acquireth a bitterness and acrimony:) so doth the residue of the blood, after its Spirits are exhausted and dispersed. For, (as we said afore) the caseous and grumous parts of the blood, being brought to the state of Fusion, by the Vital Heat, make that excrement called the Phlegma: the Saline and earthly parts consociated, make the Tar-

tar,

2.
Exemplified
in the destilla-
tion of wine.

tar, which being dissolved and kept fluid by the potulent matter (to which it is easily mixed) make the Urine: and the crass sulphur, torrifed by the Vital heat, and inseparably floating in the serum, makes the Bile, or Cholerick excrement. And this Diversity of parts in the blood is evident even to the sense, in blood let forth of either vein or artery into a vessell. For, there the caseous or grumous parts (which being most elaborate, and brought to a certain degree of Fusion, have thereby acquired a viscosity) swim on the top, in the forme of a whitish filme or membrane; while other parts of the same kind, having not attained to the like degree of Fusion and viscosity, sinck to the bottome; and the serous or watery (impregnated with the Salt, and somewhat of the crass Sulphur adust) flow round about the rest.

3. Concerning the SECOND, viz. the various
 The Various sorts of those Excrements: and their Definitions. *sorts, or Kinds of Excrements* to be separated from the blood, in order to its purification; though what we have now said, concerning their Original, may seem to intimate their several Families and specifical Differences: yet will it not be superfluous to observe further, that all of them, being Liquid, fall under two General Kinds. The *First* comprehends the *More Thin* Excrements, which are (1) the *Urine*, impregnated with the *Tartar*, (2) the *Sweat*, (3) the *Tears*, and (4) the thin *liquor* contained in the *Lympheducts*: The *Other* includes the *Lesser Thin*, which are 1) the *Phlegme* or p-tuitous

tuitious Mucus: whether it be *Acid*, such as is found in the stomach and guts ; or *Inspid*, such as the Rheum distilling from the brain by the palate and nose, the spittle, and salivous moisture excerned from the *Glandulae sublinguales* ; (2) the *Bile*, both that which is collected in the bladder of the Gall, and that deposited in the cavities of the Ears, called the *Ear-wax* ; for these two seem to be cousin Germans, and differing only in consistence.

The *Urine*, is a serous excrement, impregnated with Tartar, and tinged with a small portion of the Bile ; brought by the Emulgent arteries, into the Kidneys, together with the blood ; there separated from the blood, by a kind of percolation, thence distilling by the Ureters into the bladder, and at length avoided by the urinary passage.

The *Sweat*, is likewise a serious excrement, impregnated with a small quantity of Salt, expelled out of the capillary arteries into the habit of the body, and thence excerned through the insensible pores of the skin.

Tears also are a serous and brackish excrement, imported by the arteries into the *Carunculae Lachrymales*, or small Glandules, placed in the interior corners of the Eyes ; there separated, by a kind of percolation, from the blood ; and thence expressed, for the most part voluntarily, in griefe, and sometimes in sudden and profuse joy ; and sometimes involuntarily, in pain, fevers, &c.

The *limpid Liquor found in the Lympheducts*
(as

(at least a good part thereof) is a mild and insipid exhalation of the blood in the arteries, sweating through the coats of the smaller arteries, collected by degrees in the Lympheducts, and by them again infused into the blood, as well to prevent the coagulation, as to promote the mication thereof; and after various Circulations, avoided by evaporation through the skin.

Among the Less Thin Excrements,

The *Phlegmatick mucus* found in the stomach, is a thick viscid excrementitious juice, endowed with some Acidity, brought into the coats of the stomach, by those branches of the Celiacal artery, which are therein terminated there secerned from the blood, and by transfusion immitted into the cavity of the stomach; to the end, that it may serve to excite the Appetite, and in place of a Ferment, promote the dissolution and concoction of the meat.

The *Pituitous Mucus* found in the Guts, is an insipid excrement spewed out of the Mesenterick arteries, into the substance of the guts, transmitted by insensible passages into the hollow of them; serving to defend them from the injuries of the Chyle and excrements of the belly passing through them, and at length to be excluded together with those excrements, by stool.

That *distilling from the Brain*, is a pituitous excrement, severed from the blood brought thither by the Arteries, and excerned either
by

by the Palate, or nostrills. Such also are the sputum, which falls down from the pituitary Glandules situate about the basis of the brain: and the saliva, which is generated of humours imported into the Almonds of the Ears, the *Glandulæ sublinguales*, and other spongy parts in the jawes and mouth, and therein separated; for the moistning of the mouth, and softning of the solid meat, in mastication.

The *Bile*, or *yellow Choler* found in the bladder of the Gall, is a bitter excrement, generated in the blood, of the crass sulphur thereof (dissolved by the serum) made adust by the vital heat; separated in the Liver, and thence conveyd by convenient vessells (which we shall particularly mention anon) into the Intestines, to be excluded with the excrements of the belly.

Lastly, the *Ear-wax* is a bilious excrement, thick, yellow, and bitter, in small quantity effused out of the capillary arteries neer the Ears, and collected in the *meatus auditorius*.

The Material principles, Generation, Differences, and particular Essences of these Excrements, being thus explained; it followes that we now discuss the Manner of their separation from the blood, in the parts specified, framed by Nature to that end. Which that we may do with the more satisfaction and perspicuity; it is requisite, that we premise some short disquisition, as well concerning the Reason, why such or such Excrements (all being promiscuously blended together, or flowing

4.
The Reason, why each particular Excrement is determinately imported into the part particularly compared for its separation; is

O confusedly

confusedly together in the arteries with the blood) are yet carried into such or such parts, rather than into any others: as concerning the various wayes Nature hath contrived, for the separation of Humours each from other, in the body. For, these Generals being explicated, anticipate the remove of many of those difficulties and obscurities, that we shall encounter in our scrutiny into Particulars.

Concerning the *Former*, therefore, we advertise; that the Reason, why the Acid Phlegme contained in the blood, is imported rather into the Stomach, than into the guts; the Insipid Phlegme rather into the Guts, than into the stomach; the serum into the Kidneys, rather then into the Liver; and the Bile into the Liver, rather than into either the Stomach, Guts, or Kidneys: we say, the reason of this, is not that each particular Excrement is so directed, by any Intelligent Faculty, whose office is to distinguish not only the excrementitious parts of the blood from the benigne and profitable, but also the excrementitious one from another, and to dispense each to the part ordained for its separation: nor that each excrement is attracted by and to its like, as if the Phlegme preexistent in the stomach and guts did, by reason of similitude of substance, draw to it self those Phlegmatique particles of the blood, that hold the neereft analogy to its own nature; and so of the serum in the Kidneys, the Bile in the Liver, *Porus biliaris*, and bladder of the Gall, &c.

Not

Not by any *Intelligence*, or *distinguishing Faculty*; because the soul, or Mind (whose Function is only to ratiolate, or think) is conscious to her self of all her actions; but no mans soul is conscious of any such act, as the distinction of Excrements: And to assigne a distinct Faculty to every distinct operation in the body, is (as that wonder for Wit and Learning, *Dr. Ent*, acutely said) *Deos advocare in theatrum, ut solvant nodum fabulae*.

Not, that it is so directed by any Intelligence, or distinguishing faculty.

A course frequently taken, and eagerly pursued by many Philosophers even of the highest forme; but, in truth, so manifestly erroneous, as to refute it self. For, those fruitfull imaginations, that first hatched and introduced the *Faculties Attractive, Retentive, Concoctive, and Expulsive*; might, if they pleased, have invented and added as many more to preside over each particular humor and Excrement in the body, and multiplied them even to infinity: the difference of those Actions (and indeed of all others done in Animals) arising really from the different constitutions and structures of the organs, wherein they are performed.

Nor by *Spontaneous Motion*, or *Attraction Similary*; because in Nature there is no Motion by Attraction, but all from Impulsion; and if there were, yet could not one excrement draw another of the same kind, because *Simile non potest agere in simile, quàm simile; non magis certè, quàm in seipsum*. To which we may adde, that though many great men have laboured much to assert this opinion of Attraction *propter*

5.
Nor that it is Attracted by the like Excrement contained in that part:

ομοιωσι, by reason of similitude or familiarity of substance: yet could none of them make it so much as intelligible; and therefore *Regius* did well to say, *Excrementorum attractio & spontanea coitio, sunt rejiciendæ, quia non sunt manifestæ vel intelligibiles, nec probatæ.*

6.

But, that there is a certain peculiar Conformity of magnitude and figure, betwixt the minute particles of this or that Excrement, and the pores of this or that part constituted for the reception of it.

To what, then, shall we ascribe this so admirable effect? Why truly, according to the most of probability, to nothing else, but the Correspondence of *Magnitude and Figure* betwixt the minute particles of this or that peculiar excrementitious humor to be separated from the blood, on one side; and the small passages leading into, and insensible pores in this or that part, peculiarly constituted for the separation thereof, on the other: together with the help of that particular Fermentation, which each humor doth suffer either neer unto, or in the place of its separation; to Nature nothing being more frequent, than to make use of a certain Fermentation, greater or lesser, where she intends a separation of various humors one from another.

For, since each particular Excrement doth consist of particles of a determinate Magnitude, and determinate Figure; and that each separatory organ in the body hath likewise not only a distinct manner of Conformation of its conspicuous vessells, parenchyma, and other sensible parts; but also its insensible particles, passages, and pores, of a particular magnitude and figure, different from those of all other organs, and accommodated only to that Action or Office, for which the same was made: it is highly

highly reasonable to conceive, by way of inference, that the blood being diffused through the arteries, by the impulse of the heart, indiscriminately and equally to all parts of the body; yet each part doth admit and receive only those parts of the blood, which in respect of the magnitude and figure of their minute particles, are most correspondent or agreeable to the magnitude and figure of its slender passages and pores; and exclude the others, wherein is no such analogy or suitableness. And hence, doubtless, is it, that the serous part of the blood is determinately imported into the Kidneys; the Phlegmatique into the stomach, and guts; the Bilious into the Liver, &c. rather than into any other parts: the capillary branches of the arteries, and the insensible pores of the substance of each of those parts, being in magnitude, figure and situation respectively accommodated or adapted to the receiving and imbibing of the humor brought to it.

And for the Separation of each of these Humours thus admitted into these or those parts; we conceive it likewise to belong to the very same Cause, as their Reception or Admission doth; *viz.* to the determinate magnitude and figure of the insensible passages and pores in the Parenchyma of this or that part. Because the separation of each Excrement is effected by a kind of Cribration, or Percolation; and in all percolations, the particles of the matter transmitted, ought both in magnitude and figure, to hold an analogy with the pores of the body, through

7.
Which is also
the Cause of
the separation
of particulas
Excrements, in
particular
parts.

through which they are transmitted. Now, that the Parenchymata of the separatory organs named, are endowed with various secret passages and pores of different magnitudes and figures; is manifest from hence, that their component particles are variously contexted, (in one more loosely, rarely and thinly, in another more closely, densely and thickly) and the vessels and Fibers running through them as variously formed, in magnitude, longitude, position, number &c. and where such variety is, it doth necessitate an equal diversity of pores, which are nothing else but the void spaces betwixt the solid particles. And, that these Excrements may be (to omit, that they are) easily transmitted through such narrow and slender passages and pores, however inconspicuous and undiscernable by the sense; cannot appear difficult, or incredible to any man, who shall but observe, how blood will issue forth of the skin, if it be pricked with the point of even the smallest needle. And thus much of the *Former part* of this *previous Disquisition*.

8.

The Differences of Colatures, used by Nature in the separation of Humors in the body.

As for the *Other*; though the *Colatures*, which Nature hath instituted, for the separation of Humors in the body, be manifold and various: yet may they all be commodiously reduced to *Two Kinds*, all being in order either to *Nutrition*, or to *Excretion*.

Of the *First Kind*, we have an example in the *Nutrition* of the Fibers and Membranous parts of the body. For, it is most probable, that those parts (if not all the rest) are nourished

rished by the *Succus Nutritius*, brought to them through the Nervi; and that Aliment, being somewhat glutinous, like the white of an Egg, cannot easily penetrate into their substance, without the help of a certain thin and watery vehicle; which having once done that office of introducing the *succus nutritius* into these parts, becometh thenceforth unprofitable to them, and so is presently discharged by the *Lympheducts* into more ample spaces.

Of the *Other Kind*, there are *Three distinct sorts*. Whereof the *First* is, *when the thicker humor is retained, and the thinner rejected*: of which we have an example in the Kidneys, where the serum is transmitted into the Ureters and bladder, while the pure blood is retained, to be returned into the vena Cava, by the Emulgent veins. The same is also effected in the separation of Sweat, Tears, and spittle.

The *Second* (contrary to the first) is, *when the thinner humor is retained, and the thicker rejected*; as in the coats of the stomach and guts, where the Mucous Excrement or Phlegme is transmitted into their cavities, and the blood retained to be sent by the veins into the vena portæ: and in the brain, in which the like Mucus is separated from the blood, and deduced into the palate and nostrills.

The *Third*, *when two humors of equal consistence or thicknesse are separated one from the other*, this being retained, and that rejected. And this Colature is performed in the parenchyma of the Liver. For, the Felleous humor, and the blood,

blood, while warm, are very neer of equall thickness : and yet hath nature found out a certain way of percolation, which easily distinguisheth and separateth them each from other. A thing far transcending the industry of man, who can make no Artificial Colature, by which two Liquors of equall consistence may be separated one from another.

These Considerations premised in the General, we now at length come to explicate the *Particular Manner*, how each Excrement is separated, in its peculiar place.

9.
The Reason
and Manner
of the separation
of the serum
from the
blood, in the
Kidneys.

The blood in its Circulation, being, by the pulse of the heart, impelled into the Emulgent Arteries, flowes along into the several branches, or ramifications of them, and at length into the smaller furcles, or capillary arteries, which running out into smaller and smaller threads, till they become inconspicuous, lose themselves in various parts of the substance of the Kidneys, infusing the blood yet commixt with the serum, into the same. This Parenchyma or substance of the Kidneys, consisting of various parts diversly contexted and conformed, and having Pores of different magnitudes and figures, and positions running through it, whereof some pores are more accommodate in magnitude and figure, to the minute particles of the blood, and others more correspondent to those of the *Serum* : the blood taketh its way through one sort of pores, into the capillary branches of the Emulgent veins, that lye open and ready to receive it in all parts

parts of the parenchyma, and thence to lead it along into the Vena Cava; and the Serum taketh its course through the other sort of pores, into the Papillary Caruncles, which being pervious into the branches of the Ureters (in like manner variously dispersed up and down, so as to receive it from the Caruncles) convey the same into the trunks of the Ureters themselves, from whence it spontaneously destilleth into the Bladder, which by contracting of its self expelleth it in Urine. And this we conceive, to be the true manner of the Percolation of the Serum, made in the substance of the Kidneys.

When the Celiacal and Mesenterick Arteries have, by those their branches, that tend to those parts, brought the blood not yet purified from the *Phlegmaticque Excrement*, both Acid and Insipid, into the capillary arteries disseminated upon the coats of the Stomach and Intestines: in which there is a diversity of Pores or insensible passages, some direct, some oblique, in a word, some, in respect of their magnitude, figure and position, peculiarly accommodated to the admission of blood; some to the admission of Acid Phlegme; and others to the admission of Insipid: it comes to pass, that by reason of this Diversity of secret passages, the blood is impelled into the pores most analogous to its minute particles and through them into the capillary veins respondent to the capillary arteries, and thence into the larger veins, which soon discharge it into the Vena

10.
Of the *Phlegmatick Excrement*, in the stomach and guts.

P

portæ;

portæ; while the Acid Phlegme is protruded forward into those pores, that are most conformable to its minute particles, and through them at length into the cavity of the stomach; and the Insipid likewise is transmitted through those pores, that are most Symplicical to the magnitude and figure of its minute particles, into the cavity of the Guts, there to defend them a while from the injuries of the Chyle and Excrements, and upon the accession of a new supply of the like insipid Phlegm, to be excluded together with those excrements, as we said before. And this we conceive to be the way of percolation Nature useth, for the separation of the Phlegme from the blood, in the stomach and intestines.

II.
That the Bili-
ous Excrement
doth accom-
pany the
Phlegma-
tique, to the
stomach and
guts; and why.

Thus long doth the *Bilious* Excrement inseparately accompany the *Phlegmatique*, flowing along together with it through the branches of the *Celiacal* and *Mesenterick* arteries, into the coats of the stomach and guts; but, when it once comes there, it leaves its associate, the Phlegme, to be, after the manner expressed, transmitted into their cavities, and being thoroughly commixt with the blood, is propelled into the extremities of the capillary veins, answering to the extremities of the capillary arteries, that brought it thither; and from thence is carried along into *Vena portæ*, and at length into the substance of the Liver, therein to be segregated from the blood. Nor, indeed, ought this Bilious Excrement to be sooner

sooner dissociated from the Phlegmatique; or conveyed by any neerer way, or shorter cut, in direct vessels tending from the descendent trunk of the great artery, to the trunk of the *vena portæ*; and that for *Three* important *Reasons*.

First, it seems necessary that the Bilious humor should accompany the Phlegme, untill it hath brought the same into the substance of the stomach and guts; because the Phlegme, being a mucous and viscid humor, would be apt to obstruct the capillary vessels, and insensible pores of those parts, unless it were made more dilute and penetrative, by the admixture of the Bile, an humor penetrative and detergent, and so fit to prevent obstructions. This reason may receive verification from hence, that Men of a hot and cholerick constitution, and such in whom this Bilious Excrement doth abound more than in others, are seldom or never troubled with obstructions of the stomach and guts, by gross and viscid humors: whereas, on the contrary, those of colder complexions (especially Virgins *Leuco-Phlegmatique* and afflicted with the *Green-sickness*) in whom less of choler is generated, are commonly oppressed with oppilations of those parts, from abundance of tough and tenacious phlegme.

Secondly, the Bilious humor it self seems to require some certain degree of *preparation*, conductive to its future separation, before it can be commodiously imported into the Li-

ver. For, should it be convey'd into the Liver, directly out of the descendent trunk of the great artery; it could not be avoided, but some part of the Phlegme would also be carried along with it : because those humors, while they remain in the arteries, are never actually separated; and when they are, their separation is made, by the recess or going off of the Phlegme into the stomach and guts. And if any part of the Phlegme should accompany the blood into the Liver; the Liver would always be inevitably obnoxious to great obstructions, such as would soon render it unfit for the office, by Nature assigned unto it.

Thirdly, the Bile certainly is more firmly united to the blood, than the Phlegme; as being essentially radicated in the serous part thereof, so that without some further preparation, it cannot be easily severed from it. And therefore it was requisite, that the Bile should be carried about by those ambages of the stomach and gutts, that by passing through those intricate meanders, it might acquire some disposition preparatory to its succeeding separation. Now, that which gives it this previous disposition, is a peculiar Fermentation, which it undergoes in the vessels leading it along into the trunk of the Vena portæ : it being most undeniable, that the speediest means in Nature, for the separation of impure humors from pure, is by Fermentation, as may be sensibly exemplified in Wine and Beer, which
are

are soon defecated by the help of Fermentation, but never without it. These Reasons, therefore, make it evident, that Nature was guilty of no oversight or rashness, when she ordained, that the Bilious Humor should be thus carried about through such indirect and long wayes, before it arrive at the Liver; seeing that circulation doth make its separation afterward both the more safe, and more easie.

Nor did Nature play the wanton, or supererogate, when she contrived, that the blood should be carried along through all those intricate labyrinths in the Liver; forasmuch as if the blood were to be infused into the trunk of the vena cava, by some vessell immediately and directly tending from the trunk of the vena portæ, the Bilious humor, being not yet separated from it, would necessarily pollute and corrupt the whole mass of blood. To avoid that inconvenience, therefore, was it requisite, that the blood should be first diverted into the Liver, and therein defecated from its remaining impurities, before it be permitted to enter the vena cava.

When it is brought into the Liver, it doth not pass through the capillary branches of the vena portæ, into the extremities of the capillary branches of the Vena cava, immediately or *per Anastomoses*, as was long believed and taught by Anatomists; because we have the testimony of our eyes, that there are no such *Anastomoses*, or mutual Inosculation betwixt the extremities of those vessells: but, it is first

12.

Why the Blood is not carried immediately out of the trunk of the vena portæ, into that of the vena cava; but through the various meanders in the Liver.

13.

And why it is transmitted through the Parenchyma of the Liver.

percolated.

percolated through the *Parenchyma* or very substance of the *Liver*. Now, to what end is it so percolated? That percolation must certainly be in order either to some *Alteration*, or to some *Separation*. It cannot be in order to any *Alteration*, because no such thing can be imagined to be effected in the *Liver*, since the *Liquor* passing through the *Liver*, as it came in blood, so doth it go out blood. It must, therefore, conduce to the *separation* of something from the blood. And that something can be nothing but the *Bilious Excrement*; because all other *Excrements* are separated, before the blood arrive at the confines of the *Liver*: and because no other *Excrement* can be found therein. Which consideration is alone sufficient to evince, that the Office of the whole *Liver*, is to receive the blood out of the *vena portæ*, to purge it from the *Bilious Excrement*, and to discharge it so purified into the *vena cava*, thence to be conveyed into the *Heart*.

As for the *Manner* how this excellent work of Purification is performed in the *Liver*; for the better understanding the same, we are to observe.

14.
That the *Parenchyma* is the Principal part of all the *Liver*.

(1) That the *Parenchyma* is the Principal part among all those many, that make up that ample and curiously contrived organ of the *Liver*. In particular, the *Ligaments* of the *Liver* serve only to establish, or hold it firme in its natural position; the *Coat* investeth it; the *vena Portæ* brings the blood into it; the *Capsula Communis* is inter-vient to the distribution of the same blood, through

through the branches of the vena Portæ; the *Hepatick Artery* and *Nerve* serve partly to the better promotion of the blood into all parts of the parenchyma, and partly to the more quick and easie influx of the Bile into the *Porus Biliaris*; the branches of the *Vena Cava* export the blood, after its purification; and those of the *Porus Biliaris* export the Bile, after its separation: so that it is manifest, that all these several parts are in some sort or other, mechanically inservient to the *Parenchyma*; and that the *Parenchyma* is the sole part, wherein the separation of the Bile from the blood is made by an admirable artifice of percolation.

(2) That this *Parenchyma* is a kind of *Streiner*, after a peculiar manner framed by Nature, for that separation, which can be no otherways effected, but by Percolation. For, whensoever a mixt Liquor is brought into a part, and in passing through that part severed into two distinct kinds, and so by distinct wayes effused out of it again; we may be certain, that those Liquors were severed each from other by percolation made in that part; and as certain that that part is a Percolatory Instrument. And since the very same is effected in the *Parenchyma* of the Liver, while the Bile is severed from the blood; we may well conclude, that that separation is made by percolation, and that the *Parenchyma* is a kind of *Streiner*.

15.

And a kind of Streiner;

(3) That this *Parenchyma* being a lax and spongy substance, after a peculiar manner contexted,

16.

Whose particles are con-

texed after a
peculiar man-
ner, and pores
of divers sorts:
in respect
whereof, the
Bile is therein
separated from
the blood,
mechanically.

texed, and having various sorts of pores, where-
of some are in magnitude, figure and situation,
particularly comparated for the reception of
the impure blood, effused out of the extremi-
ties of the capillary branches of the *vena portæ*;
and others in like manner particularly com-
parated for the reception of the minute parti-
cles of the Bilious Excrement, and the trans-
mission of them into the extremities of the ca-
pillary branches of the *Porus Biliaris*; and o-
thers again particularly comparated for the re-
ception of the minute particles of the pure
blood, and the transmission of them into the
extremities of the capillary branches of the *ve-
na cava*: we say, these things being so, it is
reasonable to conceive, that after the impure
blood is brought into the pores of the *First*
sort, the particles of the Bile are impelled into
those of the *Second*, and through them into the
extremities of the capillary branches of the
Porus Biliaris; and the particles of the pure
blood into those of the *Third*, and through
them into the extremities of the capillary
branches of the *vena Cava*; so as the separation
of the Bile from the blood, is made in the pa-
renchyma of the Liver, only by reason of this

17.
The same in-
ferred from 4
considerables:
viz.

The equall di-
stribution of
the capillary
branches of all
the vessells in
the Liver.

diversity of its pores.

To encrease the verisimilitude of this Opi-
nion, there occur 4. things not unworthy a se-
rious remark, in this place; *viz.*

(1) That the Capillary branches of each
sort of the vessells mentioned, are distributed
equally into all parts of the Parenchyma; so
that

that the Port-vein doth dispense the blood equally into all parts thereof; and the capillary branches of the *Porus Biliaris*, being likewise disseminated through all parts of the same, lye ready to admit the Bilious humor, as fast as it is separated from the blood; and the capillary branches of the *vena cava*, being also dispersed into all parts of the same, are ready to receive the pure blood, as fast as it is detecated from the Bile. Which is some document, that this whole work of purifying the blood from the Bilious humor, is performed in the Liver, only *Mechanically*, and that with the greatest facility imaginable: nor is it possible for the greatest wit of man, to imagine any fabrique more commodious for the effecting thereof, than this of the Liver is.

(2) That the *Vena portæ*, being entred into the body of the Liver, doth acquire a certain *Pulsation* (though weak and less perfect than that of an Artery) by the benefit partly of the *Capsula communis*, that includeth it, and partly of the *Arteria Hepatica*, that accompanieth it. For, being included in the same common case with the *Arteria Hepatica*, it must necessarily be compressed, in some measure, by the systole thereof; and again be relaxed, in the diastole: and by that means suffer a certain Dilatation and Compression alternately. And being so compressed, it must impell the blood into the parenchyma; and that blood must be driven on by the next succeeding blood: so as that the motion and distribution thereof is necessarily

The Pulsation
of the Vena
Portæ within
the Liver.

Q

continued

The assistance
of that Pulsa-
tion, by the
Hepatick
Nerve.

continued by that impulse, without the necessity of any either *Similary Attraction*, or *Distinguishing Faculty*.

(3) That the *Hepatick Nerve* may be conceived also to conduce somewhat to that Pulsation of the *Vena Portæ*. For, that Nerve also is included in the *Capsella Communis*, and no less distributed upon the same, than upon the branches of the *Porus Bilarius*. And, therefore, when the *Arteria Hepatica* is dilated, this Nerve, as being contiguous to it, must be somewhat compressed; and so irritated to make some small Contraction of it self: which being impossible to be effected, without a proportionate constriction of the *Capsula Communis*; it comes to pass, that the *Vena Portæ* included in the same *Capsula*, suffereth a constriction, at the same time.

The Resuscitation of *Vitality* in the blood, in the branches of the *Vena Portæ*, within the Liver; and a new Fermentation thereof, previous to the separation of the Bile.

(4) It is probable, that this Pulsatile motion of the *Vena Portæ* within the Liver, doth cause some new *Fermentation* of the blood, and re-integrate the decayed *Vitality* thereof, in such a proportion, as may be sufficient to vivify the *Parenchyma* of the Liver, and conduce to the more easie and speedy separation of the Bili-ous impurities therein: especially considering that the Spirits of the blood brought in, are hindered from flying away (as they usually do through the thinner coats of the veins) by the thickness of the *Capsula Communis*, and so kept together to resuscitate the Mication and renew the *Vitality* thereof. That this is so, may be in part inferred from hence, that the
Vital

Vital Spirits can be no otherwise communicated to this Parenchyma ; the *Arteria Hepatica* being wholly distributed upon the *Capsula Communis*, and the branches of the *Porus Biliaris*, but never touching the Parenchyma with so much as one small furcle. Now there being no vessel that brings blood into the Parenchyma, but only the *Vena Portæ* ; that Parenchyma must of necessity be deprived of all Vitality, unless we allow the blood, brought by the *Porta*, to recover its vital disposition, by the means of the Pulsation caused in the *Porta*, and the excitement of a new Fermentation from the restraint of the Spirits. For, without the influx of vitall blood, no part can be vivified : and certain it is, the Parenchyma doth receive no blood, but only from the *Vena Portæ*. This Resuscitation of the Vitall Spirits in the blood, brought into the Liver, may be adumbrated by the example of the heart of a Viper, or other Animal of like vivacity. For, the Heart being cut out of the Viper yet alive, and placed upon a table, doth a good while retain its pulsation; and as that motion begins to decay, by reason of the consumption of the Vitall Heat, if you but drop some warm liquor upon the then languishing heart, it will instantly revive, and beat again, untill it grows cold. And such doubtless is this small spark of life re-kindled in the blood contained in the *Vena Portæ*, within the Liver : which though but small, may yet be sufficient both to enliven the Parenchyma, and to excite some gentle Fermentation

mentation in the blood, conducive to its purification in that place.

Now, to bring all this into a narrower circle; if we reflect upon the Equall Diffemination of all the foresaid vessels through all parts of the Parenchyma; upon the Pulsation of the Vena Portæ, within the limits of the Liver, whereby the motion of the blood is made more strong and quick; upon the promotion of that pulsation, by the Hepatick Nerv spontaneously contracting it self, after every diastole of the Hepatick Artery; and lastly upon the resuscitation of Vitality in the blood, and its renewed Fermentation (which always precedeth the separation of any humor from the blood): we say, reflecting upon these things, we may plainly understand, with how little of difficulty the blood is impelled into all parts of the Parenchyma, and therein separated from the Bilious impurities, only by reason of the Diversity of Pores in the same Parenchyma, according to a *MECHANICAL* way or method. Which was the difficulty that required to be removed.

18.
The various
Manners of
the Excretion
of Excrements,
after they are
separated and
collected.

When Excrements are separated, they must be Excluded; and therefore, having investigated the manner of their separation from the blood, it is requisite that we say somewhat of the Manner of their Excretion. For albeit there be no Excretion, but what is effected immediately by *Pulsion*; yet doth that *Pulsion* arise from *various causes*. In particular, One sort of Excretion is made by *simple Propulsion*;

pulsion; as that of the Serum through the substance of the Kidneys, that of the Bile into the bladder of Gall, and into the *Porus Bilarius*, and of the Phlegma into the Guts. Another is, from the *Rarefaction of the Excrements themselves*; as when the Serum, flowing together with the blood in the arteries, is rarefied by heat, and breaks forth into the habit of the body, whence at length it is excluded in sweat through the pores of the skin; and when the watery part of the blood is by way of Exhalation transmitted through the coats of the smaller arteries, and collected in the Lympheducts. And a third sort of Excretion is made, meerly by the *Spontaneous Contraction of the Parts Expelling*; such is that of the Bile out of the bladder of Gall, into the *ductus communis*; of vitious humors out of the stomach, by vomiting; and of the Urine out of the bladder, &c. So that we see, there is as little need of any *Attraction*, toward the Excretion of Excrements, as there was toward their separation from the blood.

To Explicate the Manner of the *Excretion of the Bile* somewhat more particularly; we note, that the *Porus Bilarius* is filled with that humor, by its capillary branches disseminated into the greatest part of the Parenchyma of the Liver: and the *Vesicula Fellea*, by its Fibrous roots, that are likewise disseminated into the rest of the parenchyma. And when these two *Receptacles* are thus filled with this humor, even to distention; then, being irritated or molested

190.
The particular Manner of the Excretion of the Bile.

lest by that burden, they contract themselves, and so squeeze out so much thereof, as exceeded their natural capacity: the *Vesicula Fellea* exonerating it self by the *Meatus Cysticus*, and the *Bilarius Porus* by the *Ductus communis*, out of which the excrement is convoid, by the oblique insertion, into the Guts. Which *Irritation* and *contraction* of these Receptacles, is the cause, why the Bile doth not continually and by drops destill out of the *Ductus communis* into the Guts, as the serum doth into the Ureters: but is as it were eructated by intervalls, and in good quantity at a time; those concave and membranous parts never contracting themselves, but only when they are above measure distended by a redundancy of the humor contained in them; and the efflux of the humor depending wholly upon that their Contraction.

20.
And the Cause
thereof,

That these parts do thus Contract themselves, is inferrible from hence, that all sensitive parts (among which the *Vesicula Fellea* may be accounted, in respect it enjoyeth a small Nerve derived from the sixth conjugation) are capable of *Irritation*: and therefore, whenever they are distended beyond their natural rate, or otherwayes molested; they begin instantly to make some resistance, and reduce themselves to their due laxity, by expressing what was offensive to them; and if the parts thus irritated, be concave, membranous, and fibrous, it is necessary, that their resistance be made by a Contraction of all their Fibers, whereby their cavity

ty is lessened, and some part at least of the humor distending them, is expelled. The Receptacles of the Bile, therefore, being such parts; they must have such a motion of *self-Resstitution*, upon the like occasion.

Digression.

Here (me-thinks) I perceive my Reader to put on the cloudy aspect of dissatisfaction, and to arrest me with this *curious* scruple, saying; *Doth not this Irritation and Spontaneous Contraction of Membranous and Nervous parts, when they are molested, imply a certain sense in them, distinct from the sense of Feeling or Touching, and independent upon the Common sense, or Brain?* For, whatever is any wayes moved by it self, in avoyd-
 217
 PARADOX.
 That we have a certain Natural Feeling wholly distinct from the Animal, and independent upon the Brain.
 ance or resistance of what is offensive to it; must be endowed with a sense, whereby to discern that offensiveness: according to that rule, *Quicquid contra irritamenta & molestias, motibus suis diversis nititur; id sensu præditum sit, necesse est.* But we are not conscious to ourselves of any such sense within us (as we are of all our Animal senses) whereby those parts are made sensible of their irritations; and therefore it seems, you have imagined one sense more than Nature hath made.

For the solution of this Difficulty, therefore, we *Answer*; that those Motions and Actions, which Physicians call *Natural* (because they are not instituted by the Will; but done even against it, and cannot be moderated, accelerated

ted, retarded, or suppressed, *ex Arbitrio nostro*, at our pleasure: and so have no dependence upon the Brain, that is the Common instrument of all the senses) these motions and actions, we say, are not yet made without some *sense*, naturally inhærent in the parts moved. For instance; we are certain, that in palpitations, tremblings, syncopes, swooning fits, and other Cardiacal symptoms or affections, the *Heart* doth variously move, and agitate it self; as being offended with something preternatural and noxious to it, and irritated to resist and repell the same: and this in respect only of some sense or feeling, by which it discerneth what is incommodious and harmfull. The *stomach* and *Guts*, in like manner, being oppressed and provoked by vicious humors, instantly rise in armes, and raise impetuous vomitings, nauseousness, convulsions, fluxes of the belly, and the like motions, for the expulsion of their enemies: and as we have it not in our power, to excite or suppress those commotions; so have we no particular cognisance of any such sense, which should extimulate those parts to begin and continue them. Truly, we cannot but wonder, as oft as we observe the effects of Antimony infused in wine, and taken into the stomach. It is not our Taste, that doth distinguish the tincture of the Antimony, from the wine; nor are we sensible of any disagreeableness therein to our nature, while we are swallowing it down: and yet in the stomach there is a certain sense, that discerns the offensiveness

ness of that draught, and quickly engageth the stomach to raise and contract it self, and to eject it again by vomiting; nor will it ever cease, till it be wholly discharged. Consider, how even the *Flesh* it self doth presently distinguish a poysonous puncture, from a simple one; and how soon it contracteth, condenseth and fortifieth it selfe, to expell the venome, whereupon ensue swelling, inflammation, and great pain in the part pricked, as is observed in the stinging of Bees, and Hornets, and Scorpions, and the biting of Spiders, Vipers, and other venenate Animals; and all this meerly from some sense, which teacheth the flesh that difference, and excites it to make resistance. Consider further, how the Contorsion, Falling downe, Ascent, suffocation and other violent Agitations of the *Womb* in women; proceed not from the brain, or Common sense, but from a *Natural sense* inhærent in that part, without which it could not be provoked to those impetuous strivings and motions. For, whatever is wholly destitute of sense, is wholly incapable also of being irritated to performe any action or motion, in order to its safety. Nor can we, indeed, otherwise discern what is Animate and sentient, from what is Inanimate and void of sense; but only by some *Motion* excited in it, by something molesting and irritating it: which Motion doth continually both follow and argue sense.

To evince this *Natural sense* yet further, we

R

shall

shall thus reason. We find in our selves, that we have Five External Senses, by which we perceive objects without us; but, because we do not perceive our perception, by the same sense, by which we perceive objects (for, we see with our eyes, but do not by them perceive that we see; but by the mediation of another internal sense, or sensitive organ, the Brain, by which we judge of all objects offered to the External senses): therefore is it manifest, that the common sensory is the Brain, which together with all its Nerves, and external organs annexed to those nerves, ought to be held the adequate Instrument of sensation. And we may fitly resemble it to a sensitive Root, which shooteth forth many Fibers or strings, whereof one doth see, another hear, a third taste, a fourth smell and the fifth feel.

Nevertheless, As Experience assureth us, that there are some Motions and Actions in us, whose regiment or moderation is no ways dependent upon the Brain; and therefore, by contradistinction to voluntary or Animal motions and actions, they are named *Natural*: So also doth Reason teach us, that we have a certain sense of *Feeling*, which is not referrible to the Common sense, nor communicated to the Brain, and of which we take no cognisance, but by the various effects and commotions that it causeth in our bodies. For, in this Sense, we do not perceive that we feel; but as it fares with men distracted, or otherwise agitated with any violent passion of the Mind,
who

who neither feel pain, nor take notice of objects offered to their senses : so is it with us in this Sense, which operating without our knowledge, is therefore to be distinguished from the Animal sense, and may be properly enough called a *Sensation without Sense*. And certainly such as this, is that sense observed in *Zoophytes* or Plant-Animals ; as the sensitive Plant, the Boramets or Vegetable Lamb of Tartary, Sponges, &c.

We know, there are many Animals, that have both sense and motion ; and yet have no brain, or Common sense, as Earthworms, Caterpillers, Silkworms, &c : and that there are some Natural Actions in us, which are performed without the influence or help of the brain. As Physicians, therefore, teach us to distinguish such actions Natural, from actions Animal : why may not we, with equall reason, distinguish the *Feeling Natural*, from the *Feeling Animal* ; so as to refer one to the brain the other not.

We know moreover, that it is one thing for a *Muscle* to be moved or contracted *Spontaneously* (as in Convulsion); and another, for it to be moved *Voluntarily*, or with various regulated contractions and relaxations, in order to the performance of some action intended, as Progression, or Apprehension. The Muscles, certainly, or Motory-Organs, are, in cramps and convulsions, moved spontaneously, upon their irritation by some acrimonious vapours, or other injurious cause ; no otherwise than

the body of a Fowl is moved, after the head is cut off. For as the body is tumbled up and down, and agitated by various convulsive motions of the feet and wings, yet such as are wholly confused and irregular, and of no effect either to progression or to apprehension, because the power and influence of the brain is extinguished; by the government and moderation whereof, those motions were formerly regulated either to progression, or flying: so in Convulsions, our Muscles are contracted, and our members variously agitated with irregular and ineffectuall motions; because those motions depend upon a natural sense only, without the regulating influence of the Brain, which taketh no cognizance of the injuries done to the Muscles, nor of the sense which irritateth them.

These things duly considered, Reason adviseth us, henceforth to lay aside that opinion of *DesCartes*, and his disciple, *Regius*, (both great Philosophers, and in many other things worthy to be followed) that the influx of *Animal Spirits* by the nerves, is necessary to the performance of all *Naturall Motions* and actions done in the body: and to take up this more probable one of *Dr. Harvey*, that each *Natural action* is effected by the part doing it, meerly in respect of a certain sense, whereby it feeleth what is troublesome and injurious to it selfe, and so is irritated to excite such motions of it self, as may conduce to its vindication; and this, without any influx or regiment of the Brain, or Common sense, at all.

We

We might have added further, out of the same *Dr. HARVEY* that all Motions in the body, are derivative from the *Vitall Influence of the Heart*, and wholly dependent thereupon; because, no part is longer capable of this Natural sense, than while it is irradiated and enlivened by the *Vitall Spirits* or blood flowing from the heart; for no part once mortified, *i.e.* no longer participant of the *Vitall* influence, can have any sense, or be irritated to motion. Besides, it is not unreasonable to conceive, that the strength or *Tone* of each part doth mostly consist in its enjoying a due proportion of *Vitality*: and if that *Tone* or firmness be vitiated or diminished (as soon it must, if deprived of that requisite influx), that part becomes languid, dull, and hardly capable of irritation. But this noble speculation requires to be handled with more exactness, than the narrow limits of a short Digression will admit of: and we have already said more than enough to assert, that all parts of the body have a certain *Naturall* sense of Feeling, distinct from the Animal, and wholly independent upon the Brain; which was the Problem proposed. ¶

OF RESPIRATION.

Exercitation the Eighth.

Of Respiration.

Article

I.

The Connexion of this Exercitation, to the precedent.

THE Chain of Nature, by which she connecteth various Operations conspiring to one and the same End, brings us in the next place to discourse of *RESPIRATION*; betwixt which and the *Pulsation* is a manifest affinity. For, these two Actions or Motions, as they are inservient to the conservation of the Lamp of Life, and the Generation of Vital Spirits; so do they both consist of a Dilatation and Contraction; the one of a Diastole and Systole of the Heart and Arteries, the other of a Diastole and Systole of the Breast and Lungs.

Now this *Affinity*, hath given occasion to many Physicians to conceive the Diastole and Systole of the Lungs, to be Synchronical or coincident with the Diastole and Systole of the Heart; and to refer both their motions to the same cause and Original. But, They have grossly erred, in confounding things so manifestly different. For

2.

The Disparity

(1) There are many sorts of Animals, that have

have Hearts, but no Lungs. (2) The Dilata-
 tions and Contractions of the Heart, are clearly
 distinct from those of the Breast and Lungs; as
 is evident from hence, that they are not syn-
 chronical, *i. e.* made and terminated in the
 same periods and times; one complete Respi-
 ration taking up more time, then 4 or 5 Pulses:
 and this in all Animals that have both Heart
 and Lungs.

*betwixt Respi-
 ration, and Pul-
 sation; both as
 to their Times
 or periods, and
 as to their
 Uses.*

(3) The Motion of the Heart and Arteries
 is much different from that of the Lungs, as to
 their Uses.

For, *First*, if the Pulse and Respiration have
 one and the same Final cause, and that (as
 these men have assumed) the Arteries take in
 the ambient aer through the skin, at every Di-
 astole; and exclude it again the same way, to-
 gether with the Fuliginous Exhalations of the
 blood, in every systole; and that in the space of
 time intermediate betwixt each Diastole and
 Systole, they contain both the inspired aer, and
 exhalations: then must we renounce both the
 doctrine of our Master *Galen*, that in the arte-
 ries nothing is contained, but the blood; and
 our owne experience, that confirms it.

Secondly, if the Arteries were (as the Lungs
 are) filled with aer drawn in by their extremi-
 ties; and that the quantity of aer attracted,
 were proportionate to the magnitude of each
 pulse, or to the greater or lesser dilatation of
 the arteries: then, if, while the pulse is great,
 the whole body were immersed into a bath of
 water or oyle, it would necessarily follow, that
 the

the Pulse would become much smaller, or much slower; because it is highly difficult, if not wholly impossible, that the ambient aer should pass through the bath, into the pores of the skin, and so into the arteries.

Thirdly, since all the Arteries, as well those that lye deep in the body, as those terminated in the skin, are moved with equal velocity, and at the same time; it is not possible, the ambient aer should as freely and swiftly pass through the habit of the body, into the profoundest arteries, as into those contiguous to the skin.

Fourthly, it is not credible, that Whales, Dolphins, and other Cetaceous Animals, that have Respiration, can draw aer into their arteries, at every diastole, through so vast a mass of waters, as is from the bottom to the top of the sea.

Fifthly, if in their systole, the Arteries expell the fuliginous exhalations of the blood, through the pores of the skin; why should they not expell also the vital spirits, that are far more subtile and fugitive, than those supposed Exhalations can be? Nature certainly hath made no such Colatory, as should retain the thinner spirits, and let the grosser fumes pass through. Nor is it yet sufficiently proved, that there are any such Fuliginous Exhalations generated in the heart and arteries, and afterward excluded partly by the Lungs, partly by the Arteries, in their Contractions; as are vulgarly believed. For, the blood suffereth
only

only a simple agitation, or conquassation in the ventricles of the heart, and a propulsion in the arteries: and that it can produce such an abundance of foety fumes from the blood, as Physicians have talked of; is not easie to conceive. Truth is, the blood, by reason of its heat and swift motion, doth emit some Halitus, or vapours (which streaming through the coats of the smaller arteries, are received and condensed into a thin limpid liquor by the Lympheducts) but is it therefore necessary, that it should emit Fuliginous exhalations? We confess also, that there is a certain thin Excrement of the blood and humors, which passeth through the habit of the body; but, that it should be discharged in thick clouds of exhalations, in every systole of the arteries, this is plainly impossible: because at that time the coats of the arteries are constringed and compressed, and there might be an easier egress for them, in the Diastoles, when the cavities of the arteries are dilated. So that among these many Arguments, there is not one, but doth clearly detect, and thoroughly refute the Error of those Men, who have confounded the Uses of the Arteries, and Lungs, of Pulsation and Respiration.

This capital Error eschewed, we may the more safely progress to explicate the nature of Respiration, as a thing in sundry particulars distinct from Pulsation, though perchance instituted by Nature, as in some sort subservient to the vital Faculty. And, that we may proceed

ceed methodically, it is requisite we consider (1) the *Manner* of Respiration ; (2) the *Efficient Cause* ; and (3) the *Final Cause*, or *Use* of it.

Concerning the First.

3.
Respiration
described.

Respiration [*Ἀναπνοή*] is an Action of the Breast and Lungs consisting of two contrary motions alternately successive, or of two parts, viz. (1) *Inspiration* [*Ἐισπνοή*] in which the ambient aer is impelled into the Lungs and chest, at that time dilated : (2) *Exspiration* [*Ἐκπνοή*] wherein the same aer is again expelled out of the Lungs and Chest, those parts spontaneously contracting or compressing themselves.

Concerning the *Inspiration*, the grand Question is, *whether the Breast and Lungs are dilated, because they are filled and distended with the aer ; as a bladder is distended by aer blown into it : or, whether they receive in the aer, because they are dilated ; as a pair of Bellows is filled with aer, only because it is dilated or opened by external force ?*

4.
The Efficient
Cause of In-
spiration, is the
Dilatation of
the Breast,
impelling the
ambient Aer
into the
Lungs.

To solve this difficulty, in a word, we say, the Breast is first dilated, before it can be filled with aer, and that Dilatation or heaving up of the breast is the cause of the airs rushing in at the mouth and nostrills, down the *Aspera Arteria*, or wind-pipe, into the Lungs. For, since there is no vacuity (at least no Coacervate one) in the world, nobody can be moved out of its place, but the next body must give way, and the next to that likewise give back, till such a part

part of space as is adequate to the dimensions of the body first moved, be made to receive it, and the space which it abandoned, be again fully possessed by another body succeeding into it: we say, since this is necessary, it is manifest, that the aer next incumbent on, or contiguous unto, the Breast and Abdomen being urged and impelled by the breast, while that is dilated or expanded, is forced to give back, and press the aer next to it, which likewise drives back the next aer, untill at length the compressed aer wanting room to retreat into, and endeavouring to avoid further compression, (its own Elater engaging it thereto) rusheth into the breast and there possesseth that room or part of space, which was left by the breast, when it began its motion. So that so much aer is impelled into the breast, as is driven out of its place by the superfice or outside of the breast, during its expansion or dilatation.

As for the *Attraction* of Aer into the Lungs, *ad fugam vacui*; it is a meer dream; as well because all motion is by *Impulsion*, as because Nature doth not abhor vacuity *primario* or *ex se*, but only *ex Accidente*, or in respect of the confluxibility of the insensible particles of Fluid bodyes, as we have elsewhere amply demonstrated.

In Physiolog.
Epiarro-Gass-
endo-Charlto-
nia. 1b. 1. cap.
5 pag. 40.

And if there were any Cause to be found, that might blow the aer into the breast, as it is blown into a bladder, so as to distend it; or at least, if the aer could be conceived to enter

into the breast spontaneously, or of its own accord, without impulsion, so as to force, or heave up the same: then indeed, would the Comparison betwixt the dilatation of the breast, and that of a Bladder, by wind blown violently into it, hold good, and we should not need to seek further. But, there being no such insufflating cause assignable; and it being ridiculous to imagine the aer should spontaneously move it self, so as to flow uncompelled into the cavity of the Chest (as is manifest not only in dead men, into whose breasts, though their mouths and nostrils are wide open, the aer doth not croud it self: but also in living men, when they at their pleasure keep their breasts compressed, or hold their breath, as the vulgar phrase is), it seemes much more reasonable to explain the reason of Inspiration, by that other similitude of the flux of aer into a pair of Bellows; there being no other difference betwixt the repletion of the Chest, and the repletion of a pair of Bellows, with aer, but only this; that the Bellows are opened by an externall force, and the Chest is dilated by an internal.

5.
And the cause
of Expiration,
is only the
spontaneous
contraction of
the Breast.

And as for the *Exspiration*, that is evidently from the compression of the breast and Lungs, which is the naturall motion of Restitution. For, the Dilatation being an action, whereby the parts of the Chest are distended into a position more large, than is natural to them; the Contraction seemes to be nothing else, but a certain falling down or relaxation of the parts

parts distended, whereby they spontaneously return to their natural position, and such as they hold in a dead body; and this not onely in the Lungs, but also in the Diaphragme, which in dead bodies is not extended downward to the stomach and guts (as in inspiration) but riseth upward toward the Lungs and Heart. But if it be here demanded, whether Inspiration, or Expiration be first; we answer that it is necessary that the aer should be first inspired, before it can be expired; and every ANIMAL dyes *Exspirando*, in Expiration.

Concerning the Second.

The Enquiry is, *By what cause the breast and Lungs are so dilated*, as we have asserted? And this, indeed, is a Difficulty not so soon resolved, as proposed; for, besides the obscurity of the thing it self, we find our selves benighted with the various opinions of Authors. Some wil have, that the Lungs are endowed with a certain *Faculty of Dilating themselves*, and so elevating the whole breast: as the Heart hath a pulsifick faculty, by whose virtue the ventricles contract themselves in each Systole. And, hereupon was it, that *Aristotle* (the Author of this opinion) doth compare the Lungs to a pair of Bellows, as if they did of themselves first attract the aer, and then emit it again. But, though it be true, that the Lungs are filled with aer, and emptied again, or elevated and

6.
The Dilatation of the Breast and Lungs, not from any Motive Faculty congeniall to the Lungs.

and depressed alternately, as Bellows are ; yet is it doubtfull, whether (as the hand which moves the bellows, by opening and shutting them, is the cause both of the influx and efflux of the aer in them) there be not some other part of the Chest, besides the Lungs, which being first dilated and contracted, is the cause, why the Lungs are opened and shut ? or more plainly, *whether the expansion of the Lungs be from an ingenite Faculty?* And, that the Lungs have no such Ingenite Motive-Faculty, is sufficiently manifest even from hence, that their motion is alwayes conforme to that of the Diaphragme, and from hence, that we can suppress, accelerate, or retard our respiration, as we please.

7.
Nor from the
impulse of the
blood out
of the
heart into the
Lungs.

Others derive the motion of the Lungs from the Heart, or rather the blood expelled out of the right Ventricle of the heart, through the Vena arteriosa into the Lungs, and so lifting them up. But this is erroneous, because (1) the efflux of the blood out of the right ventricle is caused by an ordinary motion purely natural to the heart; whereas (as we said even now) Respiration is sometimes arbitrary : (2) the cause of pulsation and Respiration would then be not onely one and the same, but those motions also would agree in their times and periods ; whereas scarce four, nay six, pulses are equal in time to one single Respiration : (3) the blood doth not stay long enough in the vessels of the Lungs, to keep them elevated all that while they are distended ; but is in continual motion,

tion, and in a moment circulated by the Arteria venosa, into the left ventricle of the Heart : and where it is retarded in its course, by any misaffection either in the capillary vessels, or in the substance of the Lungs (as it many times happens, in the disease vulgarly called, the Rising of the Lights) it causeth extream difficulty of breathing : (4) in great Apoplexies, while the pulse continueth good and regular, the Respiration many times ceaseth.

Others will have it, that the Lungs borrow their motion from the *Thorax*, or *Chest* containing them ; but the reason which detaineth us from assenting thereto, is, that after the chest is cut quite open, the Lungs continue their motion for a good while, and strongly : which were impossible, if they derived their motion from the chest.

8.

Nor from the motion of the Muscles of the Thorax.

9.

Now it being evinced, that the Lungs are not moved either by themselves, or by the Heart, or by the Thorax ; it remains, that they must be moved by some other part in the Breast, in which as in the first original, the motion of Inspiration doth begin : and this part seems to be no other, but the *Diaphragme*; and that for these reasons. (1) In wounds, or perforations of the breast, the Lungs instantly falling together, as it were close themselves (for some short space) while the *Diaphragme* is still elevated and depressed alternately, contracting and againe relaxing the ends of the spurious ribbs, and cartilages to which,

But from the *Diaphragme* moved by a congenite Faculty.

which it is annexed: whence it comes, that the aer rusheth violently into the cavity of the chest, and upon the elevation of the Diaphragme, is driven out again, through the wounds with impetuosity sufficient to blow out a candle. (2) Every man, in Inspiration, feels the Thorax to be dilated, and the whole Abdomen lifted up, and the ends of the lower ribs to be drawn inward: the Diaphragme being extended downward, with its middle part crowding down the stomach, liver and guts, and with its circumference or extreame parts contracting the ribs.

(3) Allowing the Diaphragme to be the *primum Movers*, among all parts inservient to inspiration, we may easily understand, why the Respiration becomes more frequent and remiss, when the stomach is full, and when the Aer is made more dense, than ordinary, by fogs and thick exhalations. For, in the former case, the Diaphragme hath not room enough to expand itself downward, as it ought, and so is compelled to compensate the smallness of its motion, by the frequency of it; and in the latter, the Lungs are so prepossessed with gross vapours, as that they cannot admit much aer at a time, and therefore the Diaphragme is necessitated to repeat its motions so much the oftner. (4) In Apoplexies (unless they be fatal) though the Respiration be almost insensible, yet the motion of the Diaphragme is continued; as may be perceived by the gentle motion of the Chest. (5) Respiration is more perturbed

perturbed and vitiated, by diseases of the Diaphragme, than by those of any other part of the breast: and it hath been observed by *Veslingius* that a *Neatoma* grown upon even the carneous part of it, caused extreme difficulty of breathing. Now, these are the Reasons that have induced us to believe, that the *Motion of Respiration begins in the Diaphragme*; which being a kind of Muscle of a peculiar figure, substance, position, and action, may as well be conceived to be extended by virtue of a certain peculiar and *ingenite Faculty*, as the Heart is by a *Pulsifick Faculty*: so that we may conclude the same to be the prime and principal instrument of Respiration Natural or Gentle.

Syntagm. Anatom. p. ii.

We say *Natural or Gentle*, by contradistinction to Respiration *Violent*, or *Arbitrary*. For, allowing of *Galen's* triple difference of Respiration, viz. *Free and Gentle*, *Violent*, and *more violent or sublime*: we conceive the *First* to depend upon the Diaphragme alone; the *Second*, to require a concurrence of the Intercostal Muscles, of which the interior serve to contract, and the Exterior to dilate the Chest; and the *last* to be effected by the Diaphragme, Intercostal, and Pectoral Muscles, all being set a work, and combining together to the motion. And, as for Respiration *voluntary*, such as we can at pleasure suppress, accelerate, or retard; that is manifestly by the help of the Intercostal Muscles, there being no other instruments of Motion voluntary, but the Muscles; and no other Muscles immediately conducting

TO.
Yet as well the Intercostal, as Pectoral Muscles are allowed to conspire with the Diaphragme, in Respiration violent and Arbitrary.

ducing to the contraction and dilatation of the breast, *ex arbitrio nostro*, but the Intercoſtal.

Concerning the *Third, viz.*

The *Final Cause, or Use of Respiration.*

II.
The *Final Cause of Respiration, not of the Refrigeration of the Heart, or Vital Flame: but of the subtilitation of the blood, which by the admision of Aer, is made the more convenient Fuel for the Lamp of life, and matter of the Vital Spirits.*

The most General opinion (to omit all others, as less considerable) is, that the principal use of Respiration, is for the *Refrigeration of the Heart*. Which though very ancient and plausible, is rather meerly Conjectural, than Areopagitical or demonstrative. For (1) As aer over-hot is injurious to the heart, so is aer over-cold: and as aer moderately cold is beneficial to the heart, when it is excessively heated; so is aer moderately hot, beneficial, when the heart is too much cooled. But, while the heart is in good temper, then the aer most agreeable to it, is neither hot, nor cold, but temperate. (2) It is inconsistent with the prudence of Nature, to make the natural heat of the heart so intense and excessive, as to require perpetual ventilation with cold aer: when it had been much easier for Her, to have kindled a more gentle fire therein at first, than to bring cold aer to the hearth with so much ado, to keep it in moderation ever after. And, in case that Fire should chance, at any time, to grow less, or languish (as it often doth, in extreme cold aer, many men being frozen to death in *Green-land, Russia*, and other Northern Countries) what provision hath Nature made for

for the reaccension or instauration of it? (3)
 If it be only the Cold of the aer, that is beneficial to the heart; then, certainly, the Water, (which is much colder than the aer) would more conveniently satisfy that necessity in Fishes, which yet cannot live without aer. (4).
 In persons of cold and Leuco-phlegmatique constitutions, there would be no need at all of Respiration; especially in frosty weather, when the heart hath as much want of warmth, as of cold, and more too. We confess, indeed, that at such times, our Respiration is more slow and rare, and in the heat of Summer, more quick and frequent; as it is also in Fevers: but the reason hereof is, that in Summer, the blood being made hotter, is sooner subtiliated into spirits, and those spirits faster consumed and dissipated; and so requires more aer to promote the subtiliation and inflammability of its spiritual parts. So that it should seem, the Aer is required rather as an Excitement, than as an hindrance to the vital Flame. We say, for the Excitation, or Accension of the Flame of life, by subtiliating the blood, and making the inflammable parts thereof more convenient Fuel for the same vitall Flame, and for the matter of the spirits, which being diffused through the whole body, serve to conserve and vivifie all the parts; no otherwile than Bellows conduce to the accension of flame in wood.

For, as the Aer blown out of a Bellows, doth promote the accension of fire, in wood,

12.

The same exemplified by

T 2

or

the accension
of flame in
wood, by aer
blown out of
Bellows.

Of Respiration.

or other combustible matter ; not by reason of any Cold (for Contraries never generate each other) but by the subtility of its particles, and the vehemence of its motion, in respect whereof it both dissipates the ashes , that hinder the ingress of the fire , and impells the particles of the fire into the pores of the wood ; so as that they penetrating more deeply into the substance thereof , invade and kindle all the inflammable particles therein contained: so doth the Aer brought into the Lungs, and commixing it self with the blood circulating through them, insinuate it self, by the Arteria Venosa, into the left ventricle of the heart ; and there partly by its subtility , partly by its expansive motion, so conspire with the pulse of the heart, as to conduce to the rarefaction and subtiliation of the more thin and inflammable parts of the blood, that so they may be made both commodious fewell for the Fire burning in the heart , and also fit matter of the vital spirits. All the difference is, there are no Ashes made in the heart , the Flame thereof being more pure, than focal-fire, and subsisting in a matter as fine and subtile, as spirits of wine. Nor are there any sooty exhalations; such as arise from oyle burned in a Lamp: but such a Flame is perpetually revived out of the blood in the heart , as is made by the purest spirits of wine set on fire.

13.
And inferred
from the
structure of
the Lungs.

This Use of the Aer inspired, may be in some sort inferred from the very structure of the Lungs. For, to what purpose doth both the

Vena

- *Vena arteriosa*, and *Arteria Venosa* divide and disperse into so many branches and furcles, throughout the lobes of the Lungs; unless it be to convey the aer brought into them (out of the *Bronchia*, or pipes derived from the *Aspera arteria*) together with the blood, into the left ventricle of the heart, there to excite the vital flame? For, certain it is, from the structure of these vessells, that the Aer doth not arrive at and enter the heart, pure and sincere (as it ought to do, in case it were to refrigerate the heart) but mixed with the blood returning out of the Lungs: which is the reason, why in the dissections of living creatures, no aer is to be found in the *Arteria venosa*, being, before it comes thither, throughly commixed or confused with the blood. Nor can we force aer into the heart, through the Lungs of a dead body; because the motion of the blood is then ceased. And this we conceive to be the Principal End, or Use of Inspiration.

As for that of *Exspiration*, it seems to be no other but the explosion of the same aer formerly received; together with the *Halitus*, or vapours of the blood, that steam from it, while it is circulating through the Lungs. For, as to that Antique opinion, of the discharging of *Fuliginous Exhalations* issuing from the heart; to the reasons by us formerly alleaged to discredit the Generation of them, we shall subjoyn two or three convincing ones, to disprove their Exclusion through the Lungs. (1) The motion of the blood out of the Lungs, by the *Arteria*

14.
The Use of
Exspiration

Arteria Venosa, into the left ventricle of the Heart, being continual and strong; doth manifestly forbid any thing to come from the Heart, into the Lungs that way: and (2) the situation of the Valves in the same Arteria Venosa, doth as much. (3) That the Aer passing to the Heart, and the (supposed) Fuliginous exhalations issuing from the Heart, should be carried through one and the same vessel, by contrary motions; is insolent to Nature, and incompetent to the oeconomy of the body.

15.
A Probleme,
of the Respi-
ration of the
Fœtus, in the
Mother's
womb.

And here we aske leave to propose a *Problem*. Certain it is, that the *Fœtus*, while in the Mother's womb, doth receive nourishment (not by the Umbilical Vessels, for in them nothing is contained, but Blood, which is not the Aliment of the parts; and the Umbilical Vein serveth onely to the Circulation of the blood, by bringing back to the heart, what the two Umbilical Arteries carried from it into the *Placenta Uterina*: but) by the *Mouth*, sucking in that milky liquor, wherein he swimmes: which *Hippocrates* long since, and *Dr. Harvey* of late, have undeniably proved. Now, this being so, doth it not seem necessary, that the *Fœtus* should also have the use of *Respiration*? For, since all *Suction* is by *Impulsion* (as we have elsewhere at large demonstrated) being caused only by the pressure of the thing sucked, by the Aer impelled in round (as we lately expressed, in the cause of the influx of the aer into the Lungs, in Inspiration) certainly,

ly, without the help of aer, the *Fœtus* cannot possibly suck in his nourishment. To this Reason (and we think it a weighty one) may be added, (1) the Authority of the *Divine old Man*, who in most expresse termes saith, *lib de Natur.*
 ἢ τοῖσιν [viz. *Fœtibus*] ἀπὸ τῆς πύλης ποιεῖται, τῶτε *pueri.*
 σώματι, ἢ πνί, *Puer ab alto respirat, & ore & nari-*
bus. (2) that Chickens breathe in their shells (through which the aer hath a more difficult passage, than through the secundines) and Fishes in the water. And as the Chicken pipes within the shell not yet broken; so hath it been observed and recorded by fundry learned and authentical Writers, that Infants have been heard to cry in their Mothers wombs: which were impossible, unlesse they enjoyed the benefit of Respiration.

(3) The posture of the Child in the womb seems to assert the same. For, as there is an ample space betwixt the coats of the Secundines, and the Child, to the end that a sufficient magazine of milk for his sustenance, might be stored up, and conserved therein; so is not that whole space filled up with that Liquor, but in the upper part there remains so much space unpossessed by any thing but Aer, as is sufficient for so gentle a Respiration, as the Infant hath need of: just as in the blunter end of an Egge, we perceive a certain empty space after the Hen hath sate upon it. And lest the *Chorion* should at any time be corrugated or shrieveled up together, and so streighten or compress either the Liquor, or the Infant;
 Nature

Nature hath affixed the same to the *Placenta Uterina*, to the end, that adhering to the bottome or upper part of the womb, it might hang fast, as an Apple hangs by its stem, or as our Globes of Glais are hung up by strings to the Seeling of a room. So that the *Chorion* thus adhæring to the *Placenta Uterina*, which is fastened to the bottome of the womb, and the *Amnios* in like manner adhering to the *Chorion*, in the same upper part; and the lower part of each membrane being depressed by the weight of the Infant, and of the Humors contained in them: it thence comes to pass, that this Natural Machine both of the Child, and Membranes (though at first it were perfectly round, as the yolk of an Egge) is afterward made of an oval figure. For, though the *Fœtus*, sitting incurved or bowed forward, as much as possible doth keep himself in a round figure, because of taking up the lesse room (for he sits with his leggs crossed, his heels drawn up to his buttocks, his elbowes resting on his knees, one hand held up close to his ear, the other to his cheek, for the more firme and easie sustentation of his head) yet, in that situation he hath need of a Mansion of an *Oval Figure*, that swimming in liquor, he might keep his head above water, and at his pleasure take in his nourishment by his mouth, and also inspire the temperate aer surrounding his head, in the void space of the *Secundines*; according to the opinion of *Hippocrates* newly recited. (4) Nor is the ingress of Aer into the womb impossible

ble. For, albeit the mouth of the womb, in pregnant women, be shut up, so as to exclude ones finger, or (as others will have it) a small probe: yet is it not so sealed or luted up, as to exclude the Aer; as may be inferred from hence, that many Femals have *superfœtations*, and more women (especially in this our moist Iland) are troubled with the *Fluor albus*, all the time of their Gravitation; neither of which could be, unless the *Cervix Uteri* were pervious: For, if there may be an ingress for the seed of the male after a former Conception; and as free an egress for the matter of the *Fluor albus*, all the time of the gestation of the Foetus: then, doubtless, *Hæc etiam penetret per cuncta meabilis Aer*. These Reasons duely perpended, though it seems a Paradox, yet is it no light and vain Conjecture, that the Foetus doth respire in the womb, at least gently and placidly, and in proportion to the pulsation of his heart; which being calmly and softly moved (as are the hearts of Dormice and other Animals, that sleep all the winter) hath but a small necessity of Aer. However, reflecting upon the singular fabrique of the vessels in the heart of an Infant unborn, which all Anatomists conceive made by the providence of Nature, only in defect of Respiration; as we proposed it a *Problem*, so we leave it to the consideration of wiser heads.

Here also we may opportunely touch upon the *Motion of the Brain*, which consisting (as that of the Lungs) of a Diastole and Systole, many

16.

The Motion of the Brain dependent, not upon Respiration but upon the Pulsation of the Arteries.

many have referred to the Inspiration and Expiration of Aer; as if the Brain were dilated for the admission of Aer, and contracted again for the exclusion of it. Whereas, indeed, this Motion doth not belong (1) to the *substance of the Brain*; for, that being very soft, tender, and delicate, seems incapable of any such dilatation and compression. Nor (2) to the *Membranes* investing the brain; because, as *Riolan* observed in the head of a Sheep, the diastole and systole of the brain hath been continued long, after part of the skull and Membranes also were cut off. But only to the *Arteries*, (1) because the Motion of the brain is exactly coincident and concordant with that of the Arteries, as may be discerned by the touch, in the heads of Infants new born, and in large wounds of the skull. (2) Because the chief Pulsation is in the upper part of the *Dura Mater*, which is conspersed with store of Arteries ascending from the *Plexus Arteriosus Mirabilis*, and disseminating themselves upon it. (3) Because *Waleus* observed, that in some persons, who fell into extrem agonies, and swooning fits, upon great fractures of the skull, the motion of the brain ceased, and was begun again, as their Pulses recovered. (4) Of what Use should the inspired Aer be to the Brain? For *Refrigeration*, it cannot be; the temper of the brain being such, as seems to require rather *Calefaction*. And, as for the *Generation of Animal spirits*; *Dr. Harvey* hath upon good reasons made it doubtful, whether there be any such or not:
and

and if there be, certainly they consist only of the purest and most subtile parts of the blood, and not of Aer, by the admission of which they must needs become more crass and unfit for those noble uses, to which they are consigned. And, therefore, *Riolan* said well; *Nec spiritibus permiscetur Aer in Cerebro, quia debent esse subtilissimi; alioquin permixtione aeris crassiores evaderent; nec tam celeriter in universum corpus excurrerent per nervos.*

Encheirid. Anatom. lib. 4. c. 2.

Nor must we here omit to touch upon the *Secondary Uses of Respiration*, which are *Manifold*. For, it serveth (1) to the *creation of the Voice* (whether Articulate, as in Man; or Inarticulate, as in Bruits) the Lungs exploding the inspired aer, through the *Aspera Arteria*, with such impetuosity and swiftness, as that its frequent and strong Elisions in the head of the *Larynx*, the throat and other parts of the mouth, cause it to yeeld a sound. (2) to the *Distribution of the Chyle* both out of the stomach and guts, through the *venæ Lactææ*, into the grand Receptacle, and out of that Receptacle into the *ductus Chyliferi*: the middle part of the *Diaphragme*, in Inspiration, depressing the stomach and guts; and its two long carneous productions lying so immediately under the Receptacle, as that they cannot be distended, but they must at the same time also distend it, and so express the Chyle out of it. (3) to the *Exclusion of the Excrements* both of the Guts and Bladder; the depression of the *Diaphragme* together with the compression of the *Abdomen*,

17.
The Secondary Uses of Respiration.

streightning and urging those parts. (4) to *Smelling* ; the odours being brought into the Nostrills together with the inspired Aer. (5) to *Coughing* , *Sternutation*, *Exscreation*, and *Emundtion* of the Nose ; while the breath is driven forth with violence and suddainly. And (6) to *assist the whole body in any strong and vehement motion* ; while , either the Inspiration being made gentle and small, and the breath kept in , the Muscles of the Abdomen and other parts are consequently stretched ; and so we are the better enabled to lift up things of great weight, or to repell things making resistence by force of impulsion or otherwise : or, after a great inspiration, a vehement and suddain expiration succeeds , and then the Muscles are extended together with the like force , so as the Armes and Legs are strengthened either in giving a blow, or leaping , or other the like efforts, to which main force is required. And thus much of *Respiration*.

OF

OF THE LYMPHEDUCTS.

Exercitation the Ninth.

Of the Lympheducts.

AMong the new Discoveries made in the Microcosme, by the Anatomists of this our age (wherein Nature seems to have rewarded the sweat and industry of her ingenious Votaries, with the knowledge of sundry Secrets, which she wholly concealed from our Predecessors) *These vessels* are not the least: nor can you have a compleat History of the Oeconomy of Nature in an Animal, without assuming both them, and the Liquor they contain, into particular consideration.

Article

1.

The Lympheducts, a new and excellent Invention.

To whom the Honour of their *Invention* doth belong, is yet in dispute. For, though that most diligent and perspicacious Anatomist, *Thom: Bartholinus*, be the man, who first wrote of them; and He challengeth the glory of their discovery wholly to Himself: yet is it well known, that our Country man, *Dr. Jos. live* (a person of singular dexterity, and admirable felicity, in dissection of all sorts of Animals, as well living, as dead) had discovered

2.

To whom the honour of their Discovery is to be ascribed.

and

and mentioned them to many Physicians of best note, and among the rest particularly to that eminent Master in Anatomy, *Dr. Glisson* (who makes gratefull acknowledgment thereof, in his most elaborate and judicious Book, *de Anatom. Hepatis*) more than a whole year, before *Bartholine* wrote his Treatise particularly concerning them. So that it being improbable *Dr. Jolive* should borrow the notice of these Water-vessels from *Bartholines* and as improbable, on the otherside, that *Bartholine* should receive the first Hint of them from *Dr. Jolive*: it seems equitable the Honour of this invention should be divided betwixt Them, as Men, whom good Fortune, conspiring with their industry, might haply bring to the investigation of the same thing, neer about the same time; notwithstanding they were divided by so large a distance, as is betwixt England and Denmark, and held no commerce each vvith other by Letters, or othervvise. But vvhoever vvas the Inventor, certain it is the Invention it self is of admirable advantage to the Republique of Physick: and therefore, vve shall briefly recite the summe of vvhat hath been vvritten concerning their *Description*, their *Origination*, their *Insertion*, and their *Uses*.

3.
Their De-
scription,

The *Lympheducts* are certain Whitish Vessels, in many places of the body running along close upon the veins, and sometimes embracing them in various circles, as the surcles of the Vine tvvine about the branches of an Elm, consisting

consisting of a very thin and transparent membranous substance, not much unlike a spiders web; in Figure for the most part roundish; in magnitude seldome exceeding a Ravens quill; furnished vvith sundry tender valves; and containing a *Liquor* thin, insipid, and for the most part vvhitish, but sometimes tinged either vvith blood, or vvith a yellowvish colour.

Of these are *two sorts*; some accompanying the larger veins in the Limbs, or exterior parts; and others associating themselves vvith the veins in the Abdomen, especially vvith the *Vena Portæ*, the *Iliacal* veins, those disseminated upon the *Testicles* in both sexes, and upon the bottome of the *womb* in Females.

4.
Differences.

Accordingly, their *Origine* is *tvvofold*; for those in the Abdomen arise either from the Liver, or from the Bladder of the Gall, or *Capsula communis*; and those in the Limbs, have their original from those parts; but, vvwhether from the capillary veins, or from the capillary Arteries, or from the extremities of the Nerves, is not yet determined. Onely vve have the late observations of *Olaus Radbeck* (Physician to Queen *Christina* of *Sueden*) to attest, that they arise almost from all parts; he having found them also in the Lungs, Mediastinum, Heart, suspensory ligament of the Liver, stomach, spleen, loyns and sundry other parts.

5.
Origination.

Their *Insertion* likevvise is *tvvofold*. For, those in the Abdomen are all terminated in the

6.
Insertion.

the grand Receptacle of the Chyle, into which as into a cistern, they infuse that thin liquor, which they carry in their pipes; that so the same being there commixed with the Chyle, may be conveyed along with it, through the *Lactææ Thoracicæ*, into the *subclavian vein*. And those above the *Diaphragme*, or such as arise from the Limbs, are inserted into the *External jugular Veins*, into which they disembogue their several rivulets. Wherefore they have no common Trunk, but (like several Springs of water) rising up here and there from divers parts, they all tend into two large channels, viz. the Receptacle of the Chyle, and the *Vena Axillaris*, that their streams may all meet in the common Ocean of the Heart.

7.
Situation and
Progress.

As for their *Situation* and *Progress*, it is thus. In the *Armes*, they creep up by the side of the *Vena Brachialis*, to which they are firmly connected, and so ascend together with it to the *Vena Axillaris*, into which they open themselves with a small inlet, or Orifice, that is guarded with a valve, set thereby Nature, to prevent the reflux of the liquor out of the *Axillary vein*. And, from the *Thighs*, many in like manner climb up in the company of the *Crural* and *Iliacal veins*, which they encircle in some places more closely, in others more laxely; and in this manner they mount up to the *Mesentery*, where together with the small branches of the *Vena Portæ*, they are terminated. Again, those issuing from the *Liver*, or *Bladder of the Gall*, do also descend in company

pany of the *Vena Portæ*, to the middle Glandule of the Mesentery, and are therein terminated. But, if with a more curious eye you trace these proceeding from the Liver, up to their very original ; you may perceive them to enter the *Capsula Communis*, of the *Vena Portæ*; and therein so to lose themselves, as that you cannot discern their progress from thence : yet it is probable, that being included in the same *Capsula Communis*, they follow the distribution of the same, and never stray from it into the *Parenchyma* of the Liver ; because, if they did, how comes it, that they are no where to be found in the parenchyma, no not in that part of it, where the *Capsula Communis* is ?

Concerning the *Liquor* they contain, there are two Difficulties, viz. (1) *Whence they receive it ?* (2) *Why they return it into the Receptacle of the Chyle, and into the Heart ?*

The *Former* is solved, by saying, that the *liquor* is derived partly from the Arteries, partly from the Nerves. That the Arteries have some share in bringing that mild and thin *Liquor* into the Lympheducts, may be argued thus. The blood, being by the Vital Heat and Motion, agitated in the Arteries, doth necessarily diffuse abundance of Vapours into those parts, into which it is immitted ; and this so much the more, because those vapours are repressed and kept in, by the thicknesse of the coats of the greater Arteries, untill they are driven into the smaller arteries, through whose thinner coats they more easily transpire.

8.

Liquor deduced partly from the Arteries, and

pire. And these vapours thus dispersed, are for the most part retained and re-collected by the Fibrous and Membranous parts, and by that means condensed into a Liquor, which makes one part of that Humor which the Lympheducts carry away. For, we are not to conceive, that that Liquor was preexistent in the Arteries, under the same form it afterward obtains in the Lympheducts ; and that being protruded together with the blood out of the Arteries into the substance of the parts, it is in those parts separated from the blood, by any kind of Percolation, as the Urine is in the Kidneys : because there are in all parts Veins answering to the Arteries, and those ample enough to export whatever liquor is by them imported : nor can any reason be given, why that watery humor should be at all separated from the blood ; seeing it is no Excrement of the blood, though it may be accounted an Excrement of the parts, from which immediately it is immitted into the Lympheducts. No Excrement of the blood, because it is again brought into the blood ; and Nature useth not to lose her labour, or to separate things each from other, on purpose to mixe them again afterward.

9.
Partly from
the Nerves.

Secondly, that the *Nerves* also contribute some part of this Liquor to the Lympheducts, may be inferred from hence ; (1) that whatsoever Liquor ariseth from vapours condensed, is perfectly pure, thin, and transparent : but this liquor is not so, and therefore it is necessary

sary some other Humor should be admixt to it, which gives it a greater thickness, than a simple distilled water usually hath. For, this whole liquor is more dense, and less diaphanous, and sometimes white like milk, sometimes tinged with yellow, and sometimes with blood, like water wherein raw Flesh hath been washed. (2) It is an opinion highly agreeable vwith Reason, that the thicker part of the Liquor found in these Water-conduits, is the Vehicle of the *Succus Nutritius*, vvhich being dispensed from the brain and spinal Marrow, to all parts for their nourishment, by the Nerves, is assimilated into their substance, leaving its thinner part (vvhich before served to promote and facilitate its distribution through the slender passages of the Nerves) to be infused into the Lympheducts, vvhich return it into the blood, for a double use, viz.

First, to prevent the *Coagulation* of the blood, to vvhich othervvise it vvould be strongly inclined. Secondly, to promote the *Mication* of the blood; for this thin liquor, being formerly advanced to the state of Volatility, or exhalation: it is easily united to the Vital blood, and doth as easily advance the mication of it.

10.

uses of that
Liquor.

But, vvhat vve here say, of the derivation of one part of this Liquor from the Nerves, vvill be more illustrated by vvhat followvs, concerning the dispensation of the nourishment by the Nerves.

OF THE DISTRIBUTION OF
THE NOURISHMENT THROUGH
THE NERVES.

Exercitation the Tenth.

*Of the Distribution of the Nourishment through
the Nerves.*

Article

I.
That the
Nervs are the
vessells carry-
ing the Nutri-
tive juyce to
the parts; ar-
gued

IN one of our precedent Discourses (as you may please to remember) we denied the Blood to be the Adequate Aliment of the Nervous, Fibrous, and Membranous parts of the body ; and transferred that noble office upon a certain milder and sweeter juice, congenerous to that spermatical Matter , of which those parts are first made up : Lest therefore, we should defraud your curiosity of such further satisfaction, as this new and paradoxicall (yet most reasonable) opinion requires ; we must no longer omit to explain (at least according to what light the excellent *Dr. Glisson* hath given, in so obscure an Argument) *From whence, and by what vessells, the Nutritive juice is distributed to all parts of the body.*

The *Thesis* is , that the proper and adequate Nutriment of the Parts , is derived to them from the Brain and Spinal Marrow , by the Nervs. : and the *Reasons* asserting it , are these.

(1) In

(1) In the *Palsy*, it is observed, that the parts resolved do at first appear somewhat tumid or swollen, by reason of the laxity of their Fibres, and the easie afflux of blood unto them. And yet it is manifest, that swelling doth not arise from the true and genuine Nourishment of those parts; because afterward they by little and little pine away, to extream leanness, notwithstanding the blood floweth as freely and plentifully to them then, as before. A pregnant argument, that the vessels, by which they ought to be supplied with nourishment, are obstructed; which vessels, certainly, can be no other but the Nerves, because both Arteries and veins are wholly exempt from any impeachment, in this Disease; and the Nerves alone fail of performing their office, as they ought.

2.
from the Atrophy, or decay of nutrition in parts affected with the Palsy, and whose Nerves have been wounded.

This may be confirmed by an observation of our owne. A certain woman having a Nerve pricked by an unskillfull Chirurgeon, as he was letting her blood in the right arme, was at first surpris'd with Convulsions of that Arme; and those ceasing, there ensued so great an Atrophy of that member, as nothing now (for the woman is yet living) remains of it but skin and bones: which extream extenuation, doubtless, is to be referred to the want of passage for the Succus Nutritius, through the principal Nerve in the Arme; no such accident (but an Aneurisme) usually following upon the incision of an Artery.

3.
from the beneficial use of Cephalique Emplastres in Consumptions from ulcerated Lungs.

(2) In a *Phthisis*, or Consumption from ulcerated Lungs, *Cephalique Emplastres* (though composed

composed of heating and drying ingredients, and in that respect seeming very incompetent for such a Disease) are found by experience to be very beneficial to the sick ; and that, not only because they stop the defluxion of humors from the head upon the Lungs : but also (and chiefly) because they warme and corroborate the Brain and Nervs , and so promote the Nutrition of the Parts. Which effect cannot be expected from their Heat and Driness, but from some comfortable influence transmitted to the Nervs , by which they are strengthened and made fit for the performance of their office, *viz.* the conveying the nourishment from the brain to the parts.

4.
From the *Fat-*
ness of men
endowed with
large, open,
spongy and
moist nerves

(3) As those persons are inclined to Leanness, who abound with blood ; so are those inclined to grow *Fat*, who *have large, moist, open, and spongy Nervs* ; for, such Nervs afford much Aliment, and distribute it easily.

5.
From the *ros-*
cid humor ex-
stilling from
wounds of the
joynts and
sinewes.

(4) It is commonly observed, that from wounds of the joynts and Nervs, there distills a certain *roscid Humor*, not much unlike the white of an Egg ; which being not likely to come from either the Arteries or veins, in respect they carry nothing but blood ; why may we not believe it to drop out of the Nervs ? Also in such wounds, in issues, in hollow Teeth, &c. there grow up frequently certain fleshy Excrescences, or Proud Flesh ; which being exceeding sensible, and subject to acute pain upon the least touch, cannot but have a very neer relation to the Nervs : and blood certainly

certainly is very unapt to produce such Excrecences, to the Generation of which some matter analogous to the sperme is necessarily required.

(5) The same may be said also of Wens and Scrophulous Tumors, which seem to derive their Seminal Matter from the dew or Gleet of the Nerves, and not from any humor effused out of the Arteries or veins; blood being a liquor partaking of too much Asperity and Acrimony, to be the material Principle of such Tumors: besides, we have the testimony of our sense, that the rudiments of such Tumors, are like Eggs included in a membranous filme, which contains a humor resembling the white of an Egg, but nothing like blood. Moreover, these Tumors frequently tend to some kind of Formation, though but an imperfect one; producing sometimes a mass or lump of Flesh, sometimes a Worme, or other such Monster; which is a strong Argument, that their primitive Matter is not blood, but a certain juyce much milder and sweeter, and brought to the parts in which they are generated, by the Nerve.

6.
From the Material Principle of Wens and Scrophulous Tumors.

(6) This Opinion is further confirmed by the Matter of the Seed, and the Manner of its preparation in the Testicles. For, the Seed seems to be generated, not of the blood (as hath been vulgarly believed) but of a matter much sweeter and more generous, brought into the Seminary vessells, from the brain, by the Nerve: forasmuch as the Nerve are both

7.
From the Matter of the seed, and the Manner of its preparation in the Testicles.

more

more copiously and more deeply disseminated into the parenchyma of the Testicles, than either the Arteries, or the veins; which is the reason, why their inward substance is white, not red. Again, their proper Coat appears to be nothing else, but a certain expansion of the Nervs inserted into them; from which Coat many small Nervs are on all parts derived to the middle of the Testicles, where meeting together, they make the long Nervous vessell, that manifestly exonerateth it self into the Chanel of the Epididymis, as may be plainly seen in the stones of a Horse, Bull, Boar, or other large Animal. As for the veins of the Testicles, they serve only to export the blood imported by the Arteries: and the Arteries themselves, though they variously diffuse themselves round about the Testicles; and accompanying the Nervs, tend in divers places from the inward coat, to the *Ductus Seminalis* (situate in the very middle of the Testicle) and are connected thereunto; yet they rarely disperse any branches, untill, reflecting from that chanel, they have begun their progresse back again toward the Circumference of the Testicle. But, there they send out some surcles to the outside of the Testicle; to the end that, those capillary veins, opening themselves into the substance of the Testicle, may the more easily receive the blood effused out of the Arteries, and so carry it off again. Because, that blood, if left there, would soon obstruct the parenchyma of the Testicles, and
disturb

Y

and

and nervous parts being much debilitated, and the roscid and Uctuous Liquor of the Nervs, deprived of its milder and sweeter part, the Succus Nutritius becomes too thin and sharp, and so is more expeditely discharged upon the joynts.

8.
from the
Glutinous mat-
ter issuing
from the ends
of broken bones,
and cemen-
ting them to-
gether again.

(7) From the Extremities of broken Bones, there sweats forth a certain Glutinous substance, very beneficial toward the uniting and cementing them together again: which liquor cannot proceed from the Arteries, whose office is only to convey the blood (a liquor vastly different from this Glew): and since besides them, and the Nervs, there is no vessell yet found out, that carries any humor from the Center to the circumference of the body; it is very reasonable to conceive, that this Glew is derived from the Nervs.

(8) The *white* of Eggs is brought into the womb of the Hen, by the Nervs. For, it hath no resemblance at all to blood; nor can it be generated of blood, unless by way of separation, but there can be no separation made in that part, in respect it is wholly destitute of any *Parenchyma*, which is absolutely necessary to the separation of any two Humors one from the other. Whereas the secretion of the *Succus Nutritius* brought by the Nervs, seems to want no *parenchyma*, and may be effected in parts the most bloodless. And that such a Secretion of the *Succus Nutritius* is made in the womb, is manifest from the great number of *Lympheducts* returning from thence, which Nature had never

ner ordained in that place, unless it were to export the thinner and superfluous part of the *Succus Nutritius* brought to the womb by the Nerves. So that the very Lympheducts seem to teach us, that the *Succus Nutritius* is derived into the womb by the Nerves; and that the watery part thereof being protruded into the Lympheducts, the more unctuous and profitable is transmitted into the cavity of the womb, there to make the *white* of the Egg.

(1) In the *Rickets* there is generally observed an *Inequality of Nutrition*, which (according to the most of probability) proceeds from the less aptitude of some Nerves, to carry the nourishment, than of others. For, that Disease seems to be seated originally and principally in the Spinal Marrow without the skull, and in the Nerves thence propagated: and therefore those Nerves must be more weak, languid, and unfit to transmit the *Succus Nutritius*, than such as arise from the Brain, or Marrow within the skull. And hence is it, doubtless, that the Head, Face, and *Viscera* of the *Abdomen* (all which derive their Nerves from the Marrow within the skull) grow excessively great: while the Arms and Legs become lean, flaccid, and enervate, as being supplied with nourishment by Nerves, issuing from the Spinal Marrow without the skull. Moreover, because it sometimes happens, that some one particular branch of this or that Nerve, is more debilitated, than the rest;

9.
From the Unequal nourishment of some part, in that *Rickets*.

thence it comes, that one part of a Limb is better supplied with nourishment, than the other; and so, by that unequal Nutrition of its parts, the whole member grows crooked. And these are (among many others) the chief Arguments, that have perswaded us, that the *Nourishment of the parts is brought to them by the Nerves.*

10.
Three grand
Difficulties,
troubling this
opinion.

Among the *Difficulties* encumbering this opinion, there are 3 that especially deserve consideration, viz.

(1) *That in the Nerves no passages or cavities can be discerned, through which the Succus Nutritius may be convey'd.*

(2) *That in the dissection of Animals alive, and the application of a ligature to any Nerve, no swelling can be observed to arise on either side the Ligature: and upon cutting off a Nerve, very little or none at all of this supposed Liquor can be discerned to distill from either end; contrary to what happeneth in the binding and cutting off any other vessel.*

(3) *No such Liquor hath yet been found in the Nerves of bodies dissected.*

And yet these Difficulties are not weighty enough to counterbalance the Reasons formerly alleadged; forasmuch as they may be easily solved, by *Answering* to the

11.
Solution of the First, asserting the possibility of the flux of the Nutritive First; that though no manifest hollowness be discernable in the Nerves (such as is in Arteries and Veins) yet is it not impossible, but the supposed Succus Nutritius may distill gently through them. For, it is well known by

by the experiment of laying the Spinal Mar-
row, or any Nerve in water, that the Nerves
are made up of many small Fibrous Fila-
ments, or threads cohæring together, with a
soft medullary substance betwixt them: much
like the Indian Canes, which, though in the
cortex so hard and compact, as to yield fire up-
on percussion with a Tobacco-pipe, and as so-
lid within as many sorts of wood; being yet
composed of many small and long Filaments,
with small perforations betwixt them, are per-
vious from one end to the other, so as a man
may without much difficulty blow his spittle
quite through them. Likewise, in the leaves
of plants, there shoots up a certain small Ner-
vous rib, arising from the Foot-stalke, by which
they are fastned to the branch; and without
which nothing of nourishment can be brought
to them. This little rib running up in the
middle, sends forth various lesser furcles or
threads equally to all parts of the leaf, so as
the whole is thereby equally nourished. And
yet, if you cut off this rib, or any one branch of
it, you shall discover none the smallest cavity
or hollownes therein, nor any drop of juice
issuing out of it, unless in the Sowthistle, Esula,
Celendine, and some few other plants, which
emit either a milky, or a yellowish juice, which
certainly is their nourishment. And though
other plants yield not, upon cutting of their
leaves, the like juice, yet most certain it is, they
are nourished with some kind of juice or o-
ther, derived to them by their Foot-stalks: So
that

juice, through
the Nerves,
notwithstan-
ding no mani-
fest Hollownes
can be discern-
ed in them.

that we can perceive no such absolute necessity of any manifest cavity in their small ribbs, for the dispensation of their nourishing juice, as this Objection seems to import ; especially when we consider, that the Motion of the Succus Nutritius in those slender Filaments or threads, is very gentle, slow, and insensible; not rapid, or Violent, as the motion of the blood in the Arteries and Veins of Animals. Now, since our sense is witness, that liquor may be transmitted through a Fire-cane though sufficiently solid and compact ; and our Reason assureth, that the Nutritive juice of Plants is distributed to all parts of the leaves, through the Foot-stalk, and little Rib running up in the middle of each leafe, though we can discern no manifest passages, or channels, through which it flowes : Why may not the nourishment of Animals be, in like manner, dispensed to the parts, through the Nerves, notwithstanding they appear destitute of any conspicuous hollownes ? But yet some Nerves there are not so impervious, but they admit a small style or probe into them; in which number are the Optique and Odoratory Nerves : and though the rest have not the like visible hollownes, yet reflecting upon this, that all the Nerves are framed for the performance of some one Common Office, it is not unreasonable to conceive, that all of them are perforated more or less, so as to be capable of conveying the *Succus Nutritius*. This may be in good part inferred even from hence, that the
Apoplexy

Apoplexy often ends in a Palsy ; in which case all Physicians grant, that the Humor oppressing and obstructing the Brain, is discharged thence upon the Spinal Marrow, and Nerves affected ; which could not be, unless the Nerves were capable of being obstructed by the Humor protruded or impelled into them.

You will reply, perhaps; *that they are capable, indeed, of the influx of Animal Spirits, unless their originals chance to be obstructed, as in the case of the Palsey: but, as for any Liquor, or Humor (of far lesse subtility, than those Spirits) it is impossible they should admit it into them.* And we may return, that the supposed Animal Spirits (nor, intruth, the Vital ones) are any where to be found in the whole body, pure or sincere, and without mixture; and therefore, if the Nerves were framed for the reception of any matter pure and distinct from all others, certainly that matter must be of a grosser substance, than simple and abstracted Spirits.

Furthermore, that there are small Channels in the Nerves, may be perceived by their Compression in our limbs, as when we have long sat upon a hard seat, or otherwise streightned our sinews ; for, in that case, we feel a certain *Stupor*, or *Numbness* (the vulgar say, their limbs are *asleep*) in that part, to which the compressed Nerves are prolonged : a certain document, that the free passage of some matter through them, is at that time intercepted; and the compression being removed, there
instantly

instantly ensues a kind of troublesome Tingling or Pricking, as if the part were pierced with needles ; and this only because what was arrested and intercepted there, begins again its former liberty of motion. These things duly weighed, we may lawfully conclude ; that it is not sufficiently evinced, that the Nerves are impenetrable by the *Succus Nutritius*, only because they have no manifest cavity.

12.
Solution of the
Second, yeeld-
ing the rea-
son, why no
swelling aris-
eth in a Nerve,
when bound
with a Liga-
ture, in a li-
ving Animal.

Second ; that in the dissection of an Animal alive, it generally happens that by reason of the extream striving and agony of the poor tortured Creature, before the dissector can come, either to apply a ligature unto, or to cut a Nerve ; all the Liquor contained therein is squeezed forth into the part, wherein the Nerve is terminated ; so that no wonder, if there appears neither swelling on either side of the ligature, nor any exstillation of liquor from the ends of the Nerve cut off. And this Violent streyning of the Nerves in dying-Animals, and the squeezing of the Liquor contained in them, into the parts to which they are inserted ; seems to be the Cause, why that *Lympheduct*, which corresponds to the Nerve bound or cut, is found more full and distended, than ordinary, as hath been of late frequently observed. And yet we have been assured by judicious and credible persons, that they have seen no small quantity of the Nutritive juice exstilling out of the *Nervous Chord of the Thigh* in a man ; and pressed some of it
out

out of the *Axillary Chord*, in Dogs.

Third, as to the *Second*; adding withall, that (besides what hath been said, of the cutting of the Nervous Fibres in divers plants, without effusion of the least drop of their Alimentary juice) the Motion of the *Succus Nutritius* through the Nerve, is neither Continual, nor impetuous, but by intervalls, and gentle, so as not to be perceived: and that all of it being forced into the parts, by reason of the strong Contention or streyning of the Nerve, in the very agony of death; and all impulsion of humors in the body, ceasing after death; it cannot seem strange, that none of the *Succus Nutritius* can be found in the Nerve of bodies dissected after death.

13.
Solution of the Third, shewing the reason, why the Succus Nutritius is not found in the nerves of dead bodies dissected.

These Grand Objections thus solved, it remains that we enquire; (1) *What is the Principium Elaborationis of the Succus Nutritius, or where it is prepared*: (2) *What is the Principium Dispensationis of it, or whence it is immediately infused into the Nerve, which convey it to the parts*: (3) *By what vessels it is imported into that principium Dispensationis*: (4) *What kind of Motion it hath in the distributing Nerve*: and (5) *What is the Cause of that Motion*.

Concerning the *First*, viz. the Parts where- in the *Succus Nutritius* is prepared, immediately before it is imbibed by the Nerve; there is good reason for us to believe, that this work is effected in the *Glandules of the Mesentery*, in the *Three Glandules of the Loins*, and in the *Thymus*, or *Glandule in the Thorax*. Which opinion

14.
What is the Principium Elaborationis of the Nutritive juice; viz. the Glandules of the Mesentery, of the Loins, and the Thymus.

Z

that

that we may the better explain, it is requisite we make a short Digression concerning the Differences and Uses of the Glandules, according to the observations, and consequent Conjectures of Dr. Glisson, and Dr. Wharton.

Of the Glandules in the body, there seem to be 3 sorts (respectively to the Nervs) whereof some are inservient to Excretion, some to Reduction, and some to Nutrition. For, though it be most true, that the Common office of all the Glandules, is *Secernere*, to make some separation; yet is it no less true, that that separation is various, as tending to Excretion in some, in others to Reduction, and in others to Nutrition; and the Matter it self, which is separated by those divers wayes of Secretion, being likewise various, the first sort being a meer Excrement; the Second, an Excrement only in relation to some parts, but profitable in relation to others, and therefore not to be excluded, but retained; and the last, the true *Succus Nutritius*.

Under the *First* Classis of those Glandules, are comprehended the *Testicles*, the *Prostates*, the *Vesiculæ Seminales*, the *Paps* in women, and the *Glandulæ Maxillares*, or spitting Glandules under the Tongue: all which are furnished with a peculiar Excretory vessell, by which they discharge and avoid some superfluous matter brought into them by the Nervs.

To the *Second* (inservient to the secretion of a humor, and the reduction of it into the veins afterward) belong the *Glandulæ Renales*, or Deputy

puty Kidneys, the Glandules *neer the Fundament*, those adjacent to the *Oesophagus*, the *Parotides*, *Axillary*, *Inguinal*, &c. Glandules. All which receive from the Nerve, a certain humor more rough and acrimonious (and approaching to the nature of the blood) than is agreeable with the *Succus Nutritius*; and therefore the Nerve, by the help of these Glandules discharge themselves of it, and retain only the more sweet, mild and profitable juice. But, because the Humor, thus rejected by the Nerve, hath some affinity to the blood, and in respect of its thinness is commodious for the more easie transportation of the blood, through the narrow meanders of the veins: therefore is it not excluded out of the body, as an absolute Excrement, but imbibed by the Glandules adjacent to the veins, and by them imported into the veins. Which seems to be the most satisfactory reason, that hath hitherto been given, why such Glandules are placed, for the most part, neer to the greater Divisions of the Nerve and veins; *viz.* that they may the more conveniently receive the humor effused out of the Nerve, and deliver it again into the veins.

And to the *Last* (in service to the *Præparation* of the true *Succus Nutritius*) belong the Glandules of the *Mesentery*, the 3 Glandules of the *Loins*, and the *Thymus*; or single Glandule in the Chest, neer the *Ductus Lacteus Thoracicus*, and in Brutes called the Sweet-bread. For, (1) as to the *Glandules of the Mesentery*; Anatome assureth us, that a great multitude

of the *Venæ Lactææ* tend unto them, and are in them distributed into furcles extreamly small; and that other small branches (or rather roots of milky veins take their beginning in the same Glandules, and progressing from thence, make a second sort or race of *venæ lactææ*, as we have more particularly declared before, in the 2^d Art. of the 3^d Exercit. Now, to what end hath Nature made these two kinds of *Venæ Lactææ*, one sort to import the Chyle into these Glands, and the other to export it? unless it be, that the Chyle should either suffer some Alteration, or be separated from some Humor, in these Glandules? Alteration it suffers none; because it is carried off again in the same forme, as it was brought in. And, therefore, it remains probable, that it is brought into the Glandules, only that it might be separated from some parts less agreeable with the nature of pure nourishment. Now, what should the Humor be, that is thus to be separated? An absolute Excrement it cannot be, because these Glandules have no peculiar Excretory vessels, as all parts inservient to any Excretion have. Nor is it like that matter, which is reduced into the veins, by the Reductory Glandules: for, if it were such, it would need no such separation at all, the rest of the Chyle soon after flowing into the subclavian vein, and it being easie for Nature to have contrived, that the chyle brought into these Glandules, might have accompanied the rest in that journey, without any intermediate Secretion. This considered,

considered, it is reasonable to conceive, that the Liquor separated from the Chyle, in these Glandules, doth not belong either to the First, or Second sort of Matter (*viz.* the absolute Excrement, and the Excrement Relative) formerly mentioned; but is the true *Succus Nutritius*. Which being granted, it is not difficult to explore, by what vessells this *Succus Nutritius* is from thence carried away. For, since it cannot be thence exported by any peculiar vessells, nor by veins; it must be by the Nerve.

(2) As for the *Three Glandulæ Lumbares*; it is probable, They also are official to the Nerve, in the same way; and that for two important Reasons. *First*, because they are furnished with *Venæ Lactææ* of both sorts, some tending to them, and others propagated from them, and exonerating themselves into the Common Receptacle: in all points like the Glandules of the Mesentery. *Secondly*, because in such Animals, as have the Glandules of the Mesentery very large, these *Glandulæ Lumbares* are either very small, or wholly deficient; and in men, in whom the Glandules of the Mesentery are but small, the *Lumbares* are great: an undeniable argument, that the same office is common to both sorts, and that the exility of those is supplied by the amplitude of these.

And (3) the *Thymus* also seems to be a *Nutritious* Glandule. For, in Infants, and other Animals new born (at which time, they grow much, and so require the more abundant nourishment) the magnitude of this Glandule doth

doth exceed that of any other in the whole body : but, in old men (who daily go down the hill of life , and so have less need of nourishment in such abundance) it dwindle's away to a smallness many times scarce discernable. Again , this Glandule hath no Excretory vessel, nor (like other greater Reducing Glandules) any hollowness within ; and therefore, we may well list it in the number of Nutritious Glandules. Add also , that it is white, soft, and very sweet , and in substance resembling the Glandules of the Paps : so that in probability , as the paps serve to prepare nourishment for the infant , *ab extra* ; the Thymus supplieth him with nourishment, *ab intra* ; receiving the same , perhaps out of the *Ductus Lacteus* in the Thorax, which in its approach to the Thymus , is usually divided into two streams or rivulets. And these are the reasons, upon which we conclude , that the Nerves take in some of the *Succus Nutritius*, out of each of these Glandules mentioned , whose use seems to be, to separate the same from the less Alimentary parts of the Chyle.

15.
What is the
Principium Dis-
persationis of
the same; viz.
the Brain and
Spinal Marrow.

Concerning the *Second* thing enquired, viz. what is the *Principium Dispensationis* , whence the *Succus Nutritius* is immediately immitted into the Nerves , which convey it to the parts requiring nourishment ? We say , that the *Brain* and *Spinal Marrow* seem to have the best title to that office, of all other parts, in respect that all the Nerves desuming their original from, and having their extremities or roots immediately

immediately fastned unto either the Brain, or Spinal Marrow, the Nutritive juice may commodiously and easily from thence distill down upon all parts of the body; according to their particular conditions and necessities.

Concerning the *Third*; viz. By what vessels the same Nutritive Liquor is brought into the brain and Spinal Marrow? We say, By the Nerves, and particularly those of the *sixth Conjugation*: For, this pair of Nerves, though they appear less than all others, at their first rising from the Brain; do yet hold a commerce with all other nerves of the whole body, and are immediately derived to more parts, than any other pair or Conjugation, which is the reason why Anatomists called them, the *wandering* or *Dispersed* pair. And the Commerce they maintain with so vast a multitude of other nerves, is founded on a threefold relation or intercourse, viz. *Complication, Consociation, and Inoculation*: all which are largely described by *Fallopious*, and after him by our excellent *Dr. Glisson*. Now, if we seriously consider the scope or design of Nature, in all those laborious and curious Connexions of Nerves, we shall find none, wherein our reason may with so much satisfaction acquiesce as in this, that they conduce to the commodious reception of the Nutritive juice and transportation of it to the principle of its Dispensation. For it seems, the Nutritive juice is first imbibed by the small branches of the Nerves of the *sixth Conjugation*; and those, though very many, being

16.

What are the Vessels importing the Nutritive juice into the Brain and Spinal Marrow; viz. the Nerves, and particularly those of the *sixth Conjugation* of the brain.

in observat. Anatomie. de Anatom. Hepatis. P. 436.

being yet too few for the transportation of so large a quantity of that rich Nectar, as is required to the nourishment of the whole body, Nature hath conjoyned with them a vast number of other Nerves, as Auxiliaries in that great work. So that it is not dissentaneous to reason, to conceive, that by these Nerves and their Coadjutors, the *Succus Nutritius* is carried to the brain and Spinal Marrow, thence to be afterward derived to all parts for their sustenance.

17.
What is the Motion of the same in the Nerves; viz. not continual, nor vehement: but by intervals, and slow and gentle; to the brain, in sleep, and from it to the members, after sleep.

Concerning the *Fourth*, viz. the Motion of the *Succus Nutritius* in the Nerves; though it be a problem of great obscurity, yet doth the light, let in at the postern gate of Conjecture discover thus much, that it is not continual (as that of the blood in the Arteries and veins) but by intervals; nor violent, but slow and gentle; as the defect of any swelling on either side of a Nerve bound about, in a living creature, doth sufficiently manifest. Nor is it unreasonable to conceive, that in a short time after each meal, immediately upon the distribution of the Chyle through the *Venæ Lactææ*, the *Succus Nutritius* is imbibed by the Nerves of the sixth Conjugation, and by them carried to the brain and Spinal Marrow. Which perhaps, is the reason, why alwayes, within an hour or two after meat, we perceive a certain dulness in our heads, together with an indisposition to motion, and a propensity to sleep, according to that proverb, When the belly is full, the bones would be at rest: and soon after,

ter, all those vanish again, and we perceive our selves more light, strong, and active than before our refection ; because then the nourishment begins to be diffused from the principle of Dispensation, outwards into the limbs and other parts of the body. And with this opinion agrees that observation of *Bartholinus* that the Lympheducts are more plainly discernable about five or six hours after meat, than at other times; as being at that time more filled with the superfluities of the *Succus Nutritius*. Nor is it improbable, that the Brain and Spinal Marrow are chiefly nourished in sleep, and that then the Nutritive Liquor is usually carried to them, relaxing them with its sweet and mild vapours, and so both inducing and prolonging sleep. From whence perhaps it comes, that after long sleeps, we perceive our brains to be oppressed and beclouded with vapours, our senses dull, and the motive-faculty enervated. Besides, in sleep all motions of humors flowing to the parts by the Nerves, seem to be suspended ; and yet the Circulation of the blood is certainly at that time more free and quick, than while we wake : So that It cannot be thought the cause of that cessation, but the Nerves onely, which intermit their office of distributing the *Succus Nutritius*, during sleep. And all this will appear more reasonable, if we reflect upon the flux of humors in the Nerves immediately after sleep. For, then the Brain and Spinal Marrow re-contract themselves, and become

A a

more

more tense; so that the *Nutritive* liquor is from thence transmitted, partly to the members to be nourished, and partly to the Glandules; as well such as serve for the excretion of its absolute Excrement, as those that serve for the reduction of its relative, *viz.* its acrimonious parts, that are returned into the blood, for the reason formerly mentioned.

18.
And what the
Causes of that
Motion, *viz.*
the motions
of the *Di-*
aphragme, of the
Brain, and of
the *Nerves*
themselves.

And concerning the *Last*, *viz.* the *Causes* of this Motion of the *Succus Nutritius*; we may be allowed to conceive (at least, untill Time shall have dispelled that Obscurity, which yet surrounds this abstruse Theoreme, and the industry of some more dextrous Anatomist pierced deeper into the mystery of the Nerves; a subject not much lesse inscrutable, than the Nature of the Soul it self, which useth them as her principal instruments: we hope, we may have the liberty to conceive) that the *Succus Nutritius* is not imported to the brain and Spinal Marrow, nor exported from thence to the members, by any Attraction similiary or Elective, against which we have formerly alledged convincing arguments, unnecessary to be here repeated: but, as the blood, and indeed all other humors of the body are moved, by meer *Impulsion*, or *Protrusion*, the immediate Cause of all motions in Nature. And the Agents, in this case impelling, we conceive to be the motions of the *Diaphragme*, of the *Brain*, and of the *Nerves* themselves.

For since the *Depression* of the *Diaphragme*, is generally admitted to conduce to the distribution

bution of the Chyle out of the stomach, guts, *Venæ Lactææ*, common Receptacle, and *Ductus Chyliferi*, successively into the subclavian Vein : by alternately compressing all those parts, and so compelling the Liquor contained in them, to flow upward ; and indeed to all other Natural motions : why may not the same be thought sufficient also to the Expulsion of the Nutritive juice, both out of the Præparing Glandules, into the Nerves of the Sixth conjugation and their Auxiliaries, and out of them into the brain and Spinal Marrow ; their position being such, as renders them no less subject to compression, by the descending *Diaphragme*, than the *Venæ Lactææ*, common Receptacle, and other *Chyliferous* parts are ?

If this seem difficult, we may have recourse to the reason of the ascension of a liquor from the bottome through all parts of a sponge, cloath, or other filamentous substance (as is experimented in the percolation of *Aqua Calcis*, made by a long piece of woollen cloath, whose one end is dipt in the water, and the other hung over the brim of the vessel containing it) which we have professedly explained in the 356 page of our *Physiology* : and seems to be the same with the reason of the ascension of the nutritive juice of all plants from the roots to the top of the branches.

And as for the *Motion of the Brain* ; though it may seem to be no other, but what is impressed upon the brain, by the Pulsation of the Arteries (ascending from the *Plexus Arte-*

riosus mirabilis chiefly to the *Dura Mater*, and copiously disseminating themselves upon it); yet, since it is credible, that the Pullation of the arteries doth promote the flux of the liquor in the Nerves, in other parts, especially such, where Nerves are either contiguous, or neer enough to *Arteries*, to participate of their impulse: why may not the motion of the Brain also, to which the Nerves are continued, serve to ex-press the liquor out of them, toward the parts wherein they are terminated? Besides, it is most certain that immediately after sleep, the whole Brain, together with the conjoyned net-work of its Nerves, becomes more tense and firme, than in sleep, which seems to render it moist and lax: and since that Tension cannot but in a manner ex-press, or squeeze forth, the liquor contained in the original of the Nerves, it is reasonable to conceive, that the motion of the *Succus Nutritius* from the brain to the parts, is to be imputed thereunto; especially it being by us observed, that the diffusion of the nourishment is chiefly soon after we awake and rise from sleep.

And lastly, as for the *Motion of the Nerves* themselves; nothing is more manifest, than that, while the Nerves and Muscles are distended in Voluntary motion, the juice contained in the Nerves must be impelled or ex-pressed to the parts, into which they are inserted; the extension of any nervous body, necessitating the flux of any liquor contained betwixt its filaments, from one extream to the other.

But,

But, this we deliver, not as doctrine, but meer *Conjecture*. Nor should we have adventur'd to deliver it, but that we hope, that as the singular obscurity of the Argument may incite some other more able brain to labour in the same scrutiny; so it may excuse us, if we have not been so happy, as to light upon the knowledge of the true Causes, we sought after; there being among Candid Spirits, not only pardon, but even commendation, due to ingenious Errors; especially in things of Difficulty, and where the discovery of Truth is to be hoped rather from Time and multiplied Observations, than from the single felicity of Witt.

OF

OF VOLUNTARY MOTION,

Exercitation the Eleventh.

Of Voluntary Motion, or the Use of the Muscles.

Article 1.

The Inference,
and Method of
this discourse.

FROM *one* Use of the *Nerves*, viz. the conveying of the nourishment to all parts requiring it; we now transfer our contemplation to the *other*, viz. the *transmission of the Animal Spirits from the Brain* (the principal throne of the Soul, where she judgeth of the good or evil of objects; and from whence she dispenseth her commands) to the *Muscles*, the immediate and proper instruments of Motion Voluntary: and here, for the more perspicuity, we shall take the liberty of permitting our Curiosity to exspatiate it self a while in that delightful and ample field, the admirable Art of Nature shewn in the *Structure* of those organs, in their *Variety*, and in the *Reason* of their Motions.

2.
Requisites to
Voluntary
motion.

The things required to Voluntary Motion, are (1) the *object* communicated by the sense to

to the judicatory Faculty, or Soul; (2) the Soul perceiving that object, judging it to be good or evil, and accordingly pursuing, or avoiding it; (3) the *Instrumentum Mediatum*, by which the Soul impresseth a motive-Faculty upon the Muscles, and immediately acteth, toward the attainment of her end; and (4) the *Instrumentum Immediatum*, by which immediately the motion intended is executed or effected.

Concerning the Exciting Cause, or object; and the primary Agent; there is, nor can be no dispute: it being most evident, that the Soul is the principle of Motion, and that it is excited thereunto by the good or evil appearing in the object. But, concerning the *Instrumentum Mediatum*, or that by which the Soul doth cause the Muscles to move either the whole body, or some member of it, in order to her embracing, or avoiding the object; many, especially of late yeers, have seemed very much to doubt. To satisfy them, therefore, in this particular; we (with all the Ancients) conceive, that the *Animal Spirits* sent from the brain, by the Nerves, into the Muscles, are the Immediate instrument of the Soul, whereby she doth impress an actuall motion upon the Muscles: and to evince the probability of this opinion, we offer these few, yet (in our judgment) weighty Reasons.

(1) Voluntary Motion being nothing, but the willing translation of the body of an Animal, or some part of it, out of one place, into another; moved:

3. That the *Animal Spirits* are the *Mediate Instruments*, by which the Soul moves the Muscles; argued from

4. the *Mutation of Figure* both in the Muscle and Member

nother ; it is necessary, the member moved should measure the determinate space betwixt the *Terminus à quo*, and the *terminus ad quem* ; and consequently, that the proportion of the member moved, be answerable to the proportion of that intermediate space: now from that necessary proportion, there ariseth a *change of Figure*, as well in the member moved, as in the Muscle moving (as we shall ere long demonstrate by *Principles Mathematical*, in explanation and confirmation of the doctrine of our Master Galen, in 1. *de motu Musculor. cap. 8.*) but that Mutation of Figure in the external instrument, cannot arise immediately from the Soul it self: which being Immaterial , can of her self produce no such effect: and therefore it must arise from something more proportionate to the immediate energy of the Soul, than either the grossness of the member, or muscles ordained to move it, will admit them to be ; which Something can be no other, than the Animal Spirits, whose subtility makes them to approach neerer to the nature of the Soul, and whose sudden influx through the Nerves, into the body of the Muscle, causeth a swelling or distention, and so a contraction thereof, and consequently a change of Figure in the member.

5.
the Quickness
of voluntary
motion.

(2) Since every Instrument ought to be accommodate, as well to the nature of the Agent which is to use it, as to the effect to be produced by the use of it ; and that Voluntary Motion is performed as it were in an instant and
by

by a most swift and speedy Impulse from the soul: it followeth, that betwixt the incorporeal Agent, the soul, and those corporeal instruments, the Muscles, there must be some Intermediate instrument, such as is capable of being so transmitted from the Brain, into the Muscles, with the greatest velocity imaginable, and of setting them instantly a-work, according to the determination and direction of the soul. Now, no part of an Animal can be thought capable of such easie and expedite *Mobility*, but the *Spirits*, which flow through the body in less than the twinckling of an eye: and therefore, we conclude, that They are the Immediate instrument of the soul, in voluntary motion; according to the assertion of *Galen* (in 4. de locis affect cap. 6.) in these words; *Est in cerebri Ventriculis Spiritus, Animæ primum instrumentum, quo & sensum & motum per universas corporis partes Anima transmittit, &c.*

(3) As the Power or Faculty of Seeing doth not reside in the Eye, nor that of Hearing, in the Eare, &c; but is imparted to the organs of sight, and hearing, from the soul, by the mediation of Nerves and Spirits: so likewise is not the Virtue Motive inherent in the Muscles, but communicated to them upon occasion, from the same soul, and seems to consist wholly in the quick afflux of spirits, as that by which alone they are moved. Which *Galen* also doth not obscurely intimate (in 1. de mot. Musculor. cap. 8.) where he saith, *Equipollens musculorum motus fit, quando neuter tonum Animalem habet*

6.

the conquest
of the acting
Muscle, over
its Antago-
nist.

auxiliarem; non-æquipollens Verò, cum alter solus dominatur: quare necessum est, ut vincat contractio istius musculi, qui ab Animalis Facultate adjuvatur. For, what can be understood by this *Tonus Animalis*, or *Facultas Animalis*, unless it be the distension of the conquering muscle by Animal spirits, sent from the brain, at the pleasure of the Soul?

7.
the swelling of
each Muscle,
when it mo-
veth.

(4) What's the reason, that a muscle is never moved, but it becomes more hard and swelling in the middle, than before (as is most evident in both the Masseter and Temporal Muscles, when we chew our meat) unless because it is then filled and distended with a greater gale of spirits, issued out of the store-house of the Brain? For, it seems more reasonable, that this swelling in the body of the Muscle is the Cause of its Contraction; than, on the contrary, that the Contraction should be the cause of the Swelling, as those contend who would have the motion to be performed without the afflux of spirits.

8.
the privation
of motion in a
Muscle, whose
Nerve is cut
off.

(5) If a Nerve be cut asunder, the Muscle into which it was inserted, doth for ever become incapable of motion; and this, certainly, for no other reason, but because the intercourse of the spirits betwixt the brain and that particular Muscle is wholly destroyed. So that we may well conclude, that the Soul cannot cause voluntary motion, but by the distribution of Animal spirits, through the Nerves, into the Muscles.

The necessity of Animal spirits, as the Im-
media

mediate Instrument of the soul, thus appearing; we are next to speculate the Conditions requisite in the Immediate Instrument of the Motion it self: that so we may come to a clear understanding both of the structure and diversity of the Muscles, and at length of the reason of their moving the members, the thing at which our Scrutiny is chiefly levelled.

As for the requisite *Conditions*, therefore, of this last Instrument, we observe,

(1) That in an organ of voluntary Motion is required such a Constitution, as may render it fit to receive the Animal spirits, at the pleasure and command of the soul. Which makes it manifest, that a hard, inflexible, and bony substance is most incompetent to an instrument of motion; for which reason, perhaps, *Galen* adventured to affirme, that any part made hard and stiffe by a thick Cicatrice, becomes unfit for motion: and that it must be such a part, as being soft, rare, spongy, and flexible, and distinguished with multitudes of Fibers, may most easily and readily admit the Gale of spirits flowing into its substance, and be by them filled or distended. Which is the reason, why the substance of the Muscles is for the most part *Fleshy*; than which no part, is more soft, rare, flexible, and distendible: as *Galen* hath observed (*in 1. de usu part. cap. 13.*)

9.
vvhya Muscle
is composed
for the most
part of *Flesh*.

(2) Lest the spirits might flow into this flesh, indeterminately or at randome and scatteringly; there ought to be such peculiar vessels or Conduits, which being continued from

10.
of a *Nerve*.

the brain or spinal marrow, quite home to the Flesh, into which they are inserted, may both carry the spirits thither, and preserve them from straying or dispersing by the way; and by which the Soul, or Regulating Faculty, principally residing in the brain, the original of the Nerve, may rule the members, as a Coachman rules his horses by the reins of his bridles; that we may use the same comparison with *Galen*, (1. de mot. muscular. cap. 1.). Now, the Nerve being the only parts of the whole body thus qualified, Nature most wisely inserted one, or more of them, into each Muscle. So that from this constitution of the Nerve, it appears, that they make the second Essential part of a Muscle. Nay, according to strict truth, we may adventure to say, that the Flesh and Nerve are the principal ingredients required to compleat the essence of a Muscle: because there are some Muscles (*viz.* those of the Temples, of the Forehead, of the Eyes, of the Bladder, of the Fundament, &c.) in whose bodies are neither Tendons, nor Ligaments to be found, but only Nerve, and Flesh distinguished with various Fibres.

II. (3) Because in some Members, by reason of
 Of a Ligament. their Gravity, there is a greater resistance to motion, than the Muscular Flesh (in respect of its softness and tenderness) is able to overcome; therefore ought there to be an addition of some stronger and tougher substance, which being connected or united to the Flesh of the Muscle, may both corroborate the same, and firmly

firmly conjoyn it to the bones, so as to enable it to move the ponderous member, to whose bones it is fastned. Now, this Nature foresaw, when she furnished some Muscles with *Ligaments*, especially such as were ordained to bear great stress, in moving the greater and more weighty members. Which *Galen* most elegantly expresseth thus; *Ut enim ossa, quæ dearticulantur, exactè simul ligarentur ac continentur, ne faciliè in motibus vehementioribus à sese abrumperentur; Ligamentum, quoad maximè potuit, durum, atque ab injuriis remotissimum efficere oportuit: ut autem ossibus à Musculis tractis promptè obsequeretur, molle rursus esse oportuit, atque ob id ipsum imbecillum. Atqui, forte quidem imbecillo, ac durum molli est contrarium. Quenam igitur fuerit in his Naturæ solertia, quæ corpus invenit, quod commoditatem utramque haberet, idemque ab injuriis tutum esset; ex ipsa Anatome discas, licet, &c. 12. de usu part. cap. 2.*

(4) Besides the connexion of the Musculous Flesh to the bone, by the mediation of a Ligament, there must be also something to render it prompt, easy and agile in its motion, so as to answer the celerity of the influx of the Spirits, and to fulfill the command of the Soul, as it were in an instant. Which Nature reflecting upon, superadded also a *Tendon*, or Chord, which in respect both of its subtility, and of its tough and strong Contexture, or substance, and also of its connexion to the joynt, doth make the motion more facile and quick, than otherwise it could possibly be;

as

12.
Of a Tendon:

as appears in the Muscles of the Hands and Feet, &c.

13.
of a Membrane
investing it:

(5) That these parts named, viz. the Flesh, Nerve, Ligament and Tendon, might not be endangered by lying uncovered or confused; therefore hath Nature cloathed the whole Muscle with a proper *Membrane* or Coat: which hath these two further Uses, that it causeth the Muscles that are contiguous, to slip up and down easily and without enterfearing each other, and preserves the spirits immitted into the body of the muscle moved, from passing quite through, or dispersing themselves, which they are apt to do, both in respect of their subtility, and of the force of their impulse.

14.
and of Arteries
and veines.

(6) And lastly, since this organ of voluntary Motion is to be continually supplied with life, as being *pars corporis vivens*; therefore is it provided of Arteries and veins: those to bring in the vital blood, by whose irradiation all parts of the muscle are made participant of life; and these, to return the blood to the Heart, therein to receive a new impression of life.

15.
That a Muscle
is the Imme-
diate Organ of
Motion Vo-
luntary.

Now, seeing that in the whole body of an Animal, there is no other part that hath any the least title to this Description; it is undeniable, that a Muscle is the adequate or proper and immediate instrument of Motion voluntary: and may conveniently be defined to be, *A part of an Animal, endowed with life, composed of a Nerve and Flesh, and frequently also of a Ligament and Tendon covered with a membrane,*
and

and so framed to be the proxime organ of Voluntary Motion. And thus much of the Structure of the Muscles.

As for the next Considerable, the Differences of the Muscles ; they are many , as being defumed from their substance, quantity, figure, situation, original, insertion, Fibres, parts, Use and Action.

In respect of their Substance , some Muscles are mostly composed of *Flesh*, as the *Sphincters*, and the Muscles of the *Tongue* : others are mostly *Nervous* and *Membranous*, as the *Fascia lata* abducing the leg, &c. 16.
Differences of
Muscles, in
respect of their
substance.

In respect of Quantity, which comprehends Quantity ; the 3 dimensions of Longitude , Latitude, and Profundity. Some are *Long* , as the *Musculus rectus* of the Abdomen , the *Thylers* Muscle in the thigh : and others *short*, as the *Musculi Pyramidales* in the bottom of the Abdomen. Some are *Broad* , as the *Oblique* and *Transverse* Muscles of the Abdomen , the *Latissimus dorsi*, *brachium deprimens*, &c: others *Narrow* , as the Muscles of the *Fingers* and *Toes*, &c. Some *Thick*, as the two *Vasti*, or Huge Muscles in the thigh : others *Thin* and slender, as the *Musculus Gracilis* bending the leg, &c.

In respect of Figure , some are *Triangular*, some *Square*, some *Pentagonal*, some *Pyramidal*, some *Round*, some *Oblong* ; and others of other shapes ; as the Muscles *Deltoides*, *Rhomboides*, *Scalenus*, *Trapezius*, &c.

In relation to their Situation, some are *Right*, some *Oblique*, some *Transverse* (understand it in respect ;

respect of their Fibres) some *Above*, some *Below*, some on the *right* side, some on the *left*, some *before*, and some *behind*. Where we may note in the general, that oblique muscles serve to oblique motions, Right to exact Flexion, or Extension; and such as are seated within, conduce to Flexion; and such as are posited without, to Extension.

Origination; In respect of their *Original*; some arise from *Bones*, and that either from the *Heads* of them; as most of the greater Muscles; or a little below, or from the *Glene*, some *sinus* or small hollowness in the bone: some only from *one* single bone, some from *two* or *three*: some from *Cartilages* or *Gristles*, as the Muscles proper to the *Larynx*: some from the *Membrane* enshrouding the Tendons, as the *Musculi vermiculares*: and others from other parts, as the *Sphincters* of the Bladder, and Fundament.

Insertion; Their *Insertion* considered; some are inserted into *Bones*, some into *Cartilages*, as the Muscles of the *Eye-lids*, and of the *Larynx*; others into a *Membrane*, as the Muscles moving the *Eyes*; others into the *skin*, as those of the *Lips*: some arising from divers parts, are inserted only into one; and on the contrary, some arising only from one part, are terminated in many.

Parts; In respect of their *Parts* (by which we must now understand not only such, whereunto as chief ones every Muscle is divided, but those also upon which it is seated); there are various differences. The parts into which each Muscle is

is

is commonly divided, are the *Head*, or Beginning; the *Belly*, or Middle; and the *Tail*, or Tendon. Most Muscles have but one Head; yet some have two, others three: whence they are called *Bicipites*, and *Tricipites*. Most have but one Belly, yet some are double-bellied, as the Muscle shutting the *lower jaw*, of the Bone *Hyois*, whence they are named *Digastrici*. The Tendons of some are broad and membranous; of others, round; of others, short; of others, long; of some, perforated; of others, intire; of some, single; of others, multiplied. Sometimes you shall find many Muscles ending in one and the same Tendon; as, in the Leg, the *Gemelli* or Twin-Muscles, and the *Solaris*, are united into one Chord. Lastly, from the parts upon which they are seated, they sometimes borrow their names; as the *Crotaphitæ*, or Temple-Muscles; the *Rachitæ*, or *Spinati* of the back; the *Iliaci*, &c.

According to the variety of their particular and Actions. *Actions*, the Muscles admit of a triple Difference. Whereof the *First* is, that some are *Congeneres*, or *Confederates*, which both conspire to one and the same motion; as when two are Flexors, two Extensors; one possessing the right, the other the left side of the member: and others *Antagonists*, which have motions contrary to those of others; there being scarce any one Muscle, which hath not its Contrary, or Opponent; as to every Flexor is opposed a Tensor; to every Elevator, a Depressor; to every Adductor, an Abductor; excepting only

C c

the

the two Sphincters, and the Cremasters. The *Confederates* are generally equal in magnitude, number, and strength: the *Antagonists* not, but different, according to the weight of the part to be moved, and the vehemence of the motion. Thus, the Muscles bowing the Head, are only Two; while there are Twelve to lift it up; and those that shut the lower jaw-bone with the upper, are many, but those that open it, are only two; for the weight of heavy bodies doth facilitate their falling downe. The *Second* is, that some Muscles move only Themselves, as the two Sphincters: others somewhat else besides themselves. And the *Last* respecteth the peculiar motions of particular Muscles; whence some are called *Benders*, some *Extensors*; some *Elevators*, others *Depressors*; some *Adductors*, others *Abductors*; some *Rotators*, some *Circumactors*, some *Masseters* or *Eaters*, some *Cremasters* or *Hangers*, some *Sphincters* or *Constrictors*, &c. And thus much concerning the several *Differences* of the Muscles.

17.
That the Reason of the motion of the Muscles, cannot be explained, without having recourse to Mathematical principles.

As to the *Reason* and *Manner* of their Motion (an Argument, as singularly delightfull, so singularly difficult) forasmuch as the Locomotion of the whole body, or any one member of it, being considered *per se*, meerly as Motion, without reflecting upon the end of it, seems to be an effect purely *Mathematicall*; as well, because it is a *Commensuration* of the length of the space betwixt the *Terminus à quo*, & *ad quem*; as because it is a resistance and overpowering of *Gravity*: therefore shall we lay down

down some few *Mathematical* principles, of plain concernment in the explication of it, such as without which our disquisition into the nature of Voluntary Motion would be obscure and unsatisfactory.

Fundamentals Geometrical.

Proposition, 1.

What are equal to the same, are equal also among themselves: & *è contra*.

18.
Principles Geometrical, of necessary importance toward the understanding thereof.

Proposition, 2.

All right lines drawn from the Center to the Circumference, are equal.

Proposition, 3.

Two right lines whatsoever, mutually cutting each other, make, at the *vertex*, Angles equal among themselves.

Proposition, 4.

The squares of equal lines, are equal.

Proposition, 5.

A right line, falling upon two right lines equidistant, or parallels, makes equal Angles.

Proposition, 6.

In Triangles, where the Angles are equal, the sides also are equal and proportional.

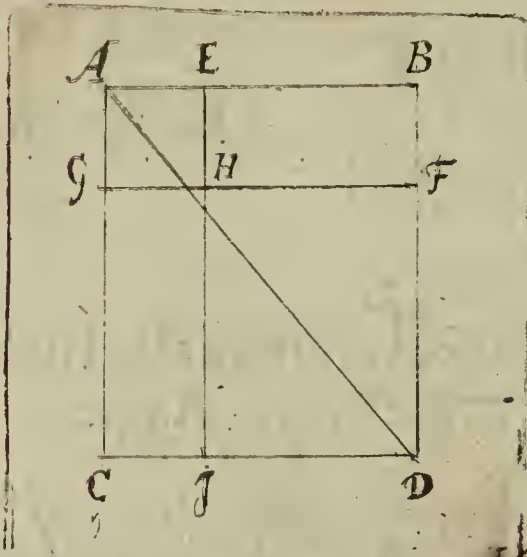
proposition, 7.

In a Triangle, where any one Angle is greater; there the side subtending that Angle, is also greater.

proposition, 8.

In every Parallelogram, the Complements of those Parallelograms, that are about the Diameter, are equal among themselves.

Demonstration.



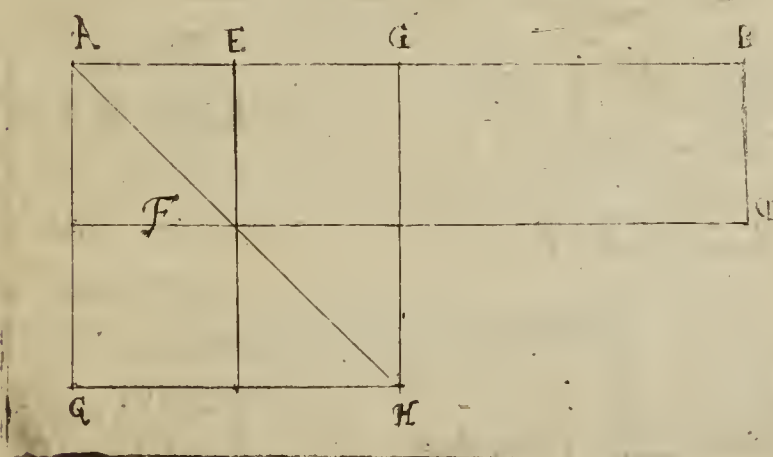
Suppose $ABCD$ the Parallelogram; AD , the Diameter or Diagonal; and the supplements HB , and HC . We say, the supplement HB is equal to the Supplement HC . because the Parallelogram hath for its Diameter AD : and therefore the Triangle ABD is equal to the Triangle ACD . Again, because $AECH$ hath its diameter AH . therefore the Triangle AGH is equal to the Triangle AEH . By the same it is demonstrated, that the Triangle HFD is equal to the Triangle HID . Now, since the Triangle AGH is equal to ID ; and EHG equal to FDI : it followes, that the supplement HB is equal to HC . Which was to be demonstrated.

Pro-

proposition, 9.

If a streight Line be divided into parts equal and unequal; the Parallelogram, that is contained in the unequal segments of the whole Line given, together with the square of that which is between the segments, will be equal to the square described by the half Line.

Demonstration.



Let the right line be AB , divided into equal parts, at the point C ; and into unequal, at the point E . Let from the point A , to the proportion of the equal segment, be made a square $ACGH$; and from the point E , on the unequal segment, be drawn a parallel line EF ; and from the point A , the Diameter or Dimetient AH ; and a parallelogram $EFBD$. We say, the Parallelogram ED . with the square FH . is equal to the square AH : which is proved from the Antecedents.

proposition, 10.

To make a Square equal to a Parallelogram given.

Let

Fundaments *Architectonical*, out of
Vitruvius, lib. 10. cap. 8.

19.
Principles *Architectonical*, of
the same Con-
cernment.

Proposition.

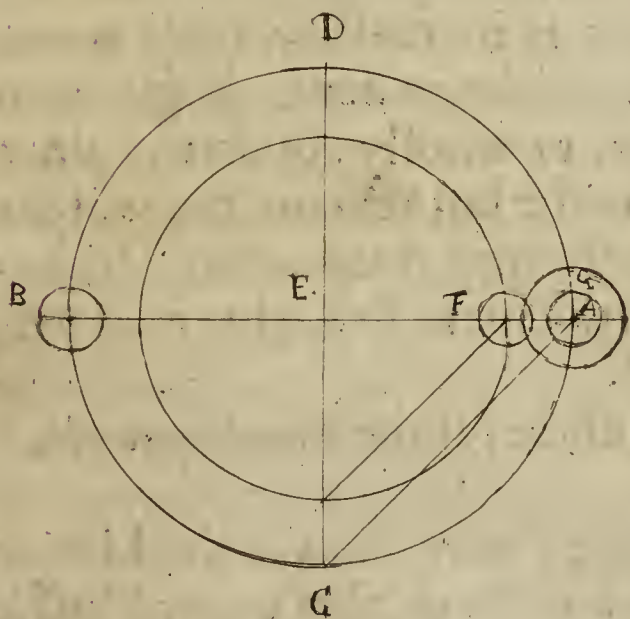
1. In the Center all Gravity ceaseth ; so
that therein nothing is either Heavy or Light.

2. The power of all Motion is varied, accor-
ding to the ration of the Center to the Cir-
cumference.

3. By how much the more remote or elon-
ged from the Center, any thing is ; by so much
the swifter is it moved.

4. By how much greater the Circumfe-
rence of the Circle, so much greater the
Diameter, and so much swifter the Motion.

Demonstration.



Let the
Center be *E*.
from which
under the
Diameter *E*
F. let the
weight be
placed at *F*.
We say, this
weight at *F*.
doth not rest
there, but
moveth to its
Center, to-

wards *C*. Again, if the same weight be elon-
ged, or removed to *A* ; then by reason of its
greater

greater distance from *E*, and of the greater Circle; it will be moved towards its Centre *C*, with the greater velocity accordingly.

5. Bodies equal, and under the same Diameter, equally distant from the Center; do cutt a perpendicular Line at right Angles.

Demonstration.

In the former Scheme, let one body be at *B*, and another at *A*. upon the Diameter of the Circle, whose Center is *E*. and neither of them shall move, because their Gravity is equal, in that proportion of the Diameter, and so hasten to the Center *C*. with equal swiftnes; but, because they make equal Angles with the perpendicular *DE*.

6. If to one of two equal bodies, placed under the same Diameter, and equally distant from the Center, any weight be superadded; that, whose weight is increased, shall move more strongly, and make an acute Angle with the perpendicular, or wholly obtain the place of the Center: as in the last Scheme, the weight *A* is encreased to the magnitude *G*; and therefore it must move the more strongly; as is evidently concluded.

And let these suffice for the *Fundamentals*.

To come to their *Concernment* in the Motion of the Muscles, we observe, that every Muscle hath a twofold Motion, viz. one *Natural*, wherein the Fibers of the muscle spontaneously recontract themselves, after they have been
exten-

extended, or restore themselves to their native tenour ; by Philosopher named, the motion of *Restitution*, common to all *Tensile* bodies : and this is alwayes from the end , towards the beginning of the Muscle, according to the position of its Fibers : another, *Animal*; wherein the same Fibers are further Contracted, by the forcible and copious influx of Animal spirits , at the command of the soul , in order to the performance of some action intended.

20.
That every Muscle hath a Twofold Contraction, viz. Natural and Animal.

That the Natural Contraction of a Muscle, is not sufficient to voluntary Motion , though we allow every muscle to be made upon the stretch, *i.e.* in an extended position ; is manifest from hence , that betwixt each Muscle and its Antagonist , there is an equal power of naturally-moving themselves toward their originals ; so that betwixt two Contrary forces, the one drawing one way , the other the clean contrary , the member must be held immovable ; as appears in the 5th. *proposit. Architectonical.* Necessary it is, therefore, to voluntary Motion, that one Muscle over-power the other, not by reason of its spontaneous or Natural Contraction , but of its impressed or Animal; which depends upon the supply of spirits transmitted from the brain, by the Nerves into the Fibers of the acting muscle, and so-distending them, as to cause the whole Muscle to shorten or contract it self. And, that the power of Antagonists is, as we affirme, naturally equal ; may be concluded from hence, that if one Muscle be cut off , its Antagonist instantly

21.
That the Natural Contraction is not the cause of Voluntary Motion; but only the Animal.

D d drawes

drawes the member to its side, which before was held in the middle, and as it were æquili-
brated betwixt them.

22. Secondly, we observe; that in all Motion there are *two Terms* to be acknowledged, the one is the *point of Rest*, or the *Fundament*, in which the muscle is firmed or fastned, because all motion is *super aliquo Quiescente*: the other is in *parte Mobili*, or insertion of the muscle, from whence the Muscle, by contraction, drawes the member toward it self; and this is sometimes less, sometimes more remote from the *Center*, or point of rest, according to the less or greater resistance of Gravity in the member to be moved, and according to the less or greater vehemence required to the motion. Which Nature (whose Art is not more admirable in any thing, than in her proportioning the length of the insertion of each muscle, from the *Hypomochlion* or point of Rest, to the Gravity of the member to be moved) respecting; most ingeniously contrived a way to compensate the slender strength of divers muscles, by inserting them at great distance from the *Center* of their motion, or that point, about which the member is to be moved. For, since (according to the 1. *proposit. Architectonical*) there is no motion in the *Center*; we may easily understand, why in many muscles, ordained for strong motions, the *Terminus stabilis*, or original, is more remote from the *Terminus Mobilis*, or insertion, than in others framed for motions less strong; viz. that by even a small force

force, the muscle (which, considered in its proper bulk, or in any other position, would be insufficient to the effect designed) might elevate a great weight, as we see in the muscles of the Hand, Arms, Thighs, and other parts. For this reason also is it, that in some bones we have certain *prominences*, or Buttings forth in the end, called *Epiphyses*, and *Apophyses*, to which the muscles are fastened. The truth of all which is evinced by the 2d and 3d *proposit. Architectonical*.

These things being thus firmly established, it appears an undeniable truth, that no motion can be made, without changing the Figure of the muscle. For, since equal Angles subtend equal sides, by the 6th *Geometrical Proposition*: it follows necessarily, that in all motion, the Figure of the member moved, is changed.

23.

No Motion without change of Figure.

And, because the change of Figure doth depend on the change of Angles; therefore must we admit a threefold Figure, as there are three sorts of Angles, *viz.* (1) a right, in which neither of the two opposite muscles acteth; (2) an obtuse, which being greater than a right, is consequently subtended by a greater side; and (3) an acute, which being less, requires a less subtending line.

24.

Which is Threefold, relative to the difference of Angles.

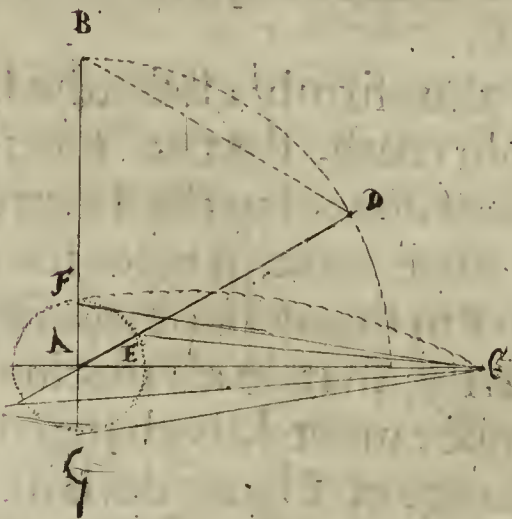
Now, forasmuch as in the *Middle Figure*, no motion can be made, because then both the opposing Muscles are equally extended: we are to demonstrate, how it is effected in both the *Extreams*. And this, certainly, is done, when one of the acting Muscles is filled or distended.

25.

All motion is made in one of the Two Extream Figures; and how, demonstrated.

stended by the Animal influx, more than its Antagonist, whereupon the Figure of the Conquering muscle is changed; and the Angle of Articulation is made more Acute, or less, by that Contraction; and that segment, detracted from the line, is in proportion to the space comprehended. For Example.

Demonstration.



Imagine the Brachium, or upper halfe of the Arme, from the shoulder to the elbow, to be CA ; and the Cubit, or lower half from the elbow to the hand, to be AB :

the Muscle bending the Arme, to be CF : and its Antagonist extending it, to be CG : and the object to be apprehended by the hand, D . Now, we say, while those two opposite Muscles GF . and CG . are equally contracted, the Appetite must fail of being satisfied, *i. e.* the hand cannot be brought to lay hold on the object desired; because the Figure or Angle of Articulation remains invariable. But, that the hand may be raised to the object, it is necessary, that Angle should be made more Acute, by contraction of the Muscle CF . in proportion to the motion of the line BD : and because

because that Angle is less, therefore is the line subtending it also less, or shorter; according to the 5th and 6th proposition. Geometrical. And, since the Line *EF*. is in proportion to the Line *DB*: it follows that so much is to be detracted from the length of the Muscle: yet, we are not to suppose, that this detracted portion of the Muscle is to be wholly cast away; in regard, then it would be incapable of the like or any other motion ever after: but, that being plumped up or filled with a gust of spirits, it is incurvated, or made Convex by that distension; and that line, which before was streight, is now changed into an Arch, and consequently made shorter.

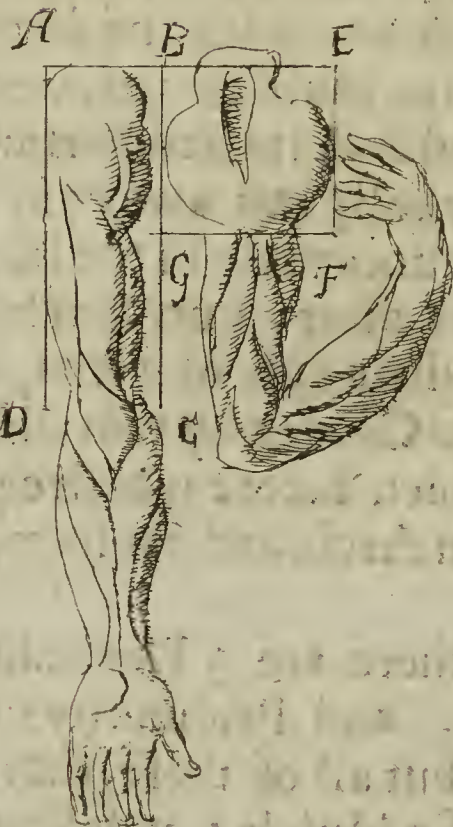
Moreover, since there are 3 Dimensions, Longitude, Latitude, and Profundity; and that it is not any one, but all of these, that determine the Figure of a Muscle: it follows, that all Muscles, while they are contracted, are as much encreased in Thickness and Latitude, as they are diminished in Longitude. Which may be naturally inferred from the importance of the 5. 7. 8. 9. and 10. propositions Geometrical; where a square is found equal to a Parallelogram.

25.

That a Muscle, in contraction, is encreased in Latitude and Profundity, proportionately to its diminution in Longitude; demonstrated.

Demon-

Demonstration.



Let the Parallelogram be $ABCD$. representing the Muscle Biceps, of the Arme, as it is extended; and a Square equall thereunto, $BEGF$, representing the same Muscle, as it is contracted. We say, that the Muscle, in its second Figure, or Contraction, hath lost nothing

of its bulk, that it had in the first Figure, or Extension: but, because the Square of the muscle, $BEGF$. is equal to the Parallelogramme, $ABCD$; therefore it followes, that the superfice of the muscle is the same, and that the part GD . changed in its Latitude, is in proportion to the Line AD . which determin's the Local motion.

26.
The Necessity
of Antagonist-
Muscles.

Reflecting upon what hath been said, we soon discover, why each Muscle generally hath its Antagonist; there being contrary motions to be performed successively by every member, and it

it being impossible, one and the same Instrument should suffice to both. Now of these Antagonists one doth bend the member, by Contracting it self; and the other by its contraction doth extend it: and both extend each other successively: that which is contracted, doth alwayes act, and that which is extended, doth not act, but suffer, and is transferred with the part moved.

But here we are to except some Muscles, which seem so sufficient to the motion of the part into which they are inserted, as to have no need of Antagonists; as all *Circular* muscles, whose motion is easily understood from the mathematical principles premised. For, since a Circular muscle hath circular Fibres, and that all contraction is made *secundum continuitatem lineæ*; it followes, that such muscles shut the part to which they are affixed, by contracting themselves toward their Center; as may be observed in the Sphincters of the Bladder and Fundament, and in the Round muscle of the Eye-lids.

27.
How Circular
Muscles are
Contracted.

Onely it may be enquired, Why those *Sphincters* have no Antagonists, as the *Clausor Palpebrarum* seems to have, the *Elevator* opening the eye-lids, as the *Clausor* shuts them? Whereof the Reason certainly is this, that both the Bladder and Fundament are not opened by muscles, but by the quantity of Excrements contained in them, which being pressed or detrued downward by the Diaphragme and muscles of the Abdomen, force open the Sphincters,

28.
Why the
Sphincters
have no
Antagonists.

Sphincters, by extending their Fibers from the Centre to the Circumferences; so that to speak strictly, the excretion of the Urine, and of the Excrements of the belly, are not actions *immediately* voluntary, as the opening of the Eye-lids is.

29.
Conclusion.

And this is all we thought necessary to be said, concerning the Use of the muscles, in general, and concerning the admirable Geometry observed by Nature in the Fabrique of them.

Should we extend our discourse, to the accommodation of the Figure and motion of each particular muscle in the whole body, to the Geometrical, and Architectonical principles premised: as we should abuse your Patience, so should we disparage your Capacity of making use of the same Clue for your guidance through the whole Labyrinth of Voluntary Motion, that we have put into your hands for your more easily entering into it. We shall conclude, therefore, with this due acknowledgment; that the *Omniscient Creator hath made all things, as in the Greater World, so also in the Lesser, Man*, in Number, Weight, and Measure.

THE

Galen. in 2. de Motu Musculor. cap. 5.

Qui evidentibus fidem abrogat, sensûs est expers ; qui verò de dubiis promptè pronunciat, temerarius est ; qui autem, propter obscuritatem, quæ in his inest, quæ etiam clara sunt & manifesta, habet suspecta ; de numero eorum est, qui dubitationibus oblectantur. Porro, qui non modò quæ suspecta habet ; verùm etiam quæ clara sunt, propter obscuritatem dubiorum, studet evertere ; extremè fatuus est. Ne igitur sponte sensum nobis ipsi adimamus, neque dubitationis æmuli, aut fatui, aut aliud ejusmodi quidvis simus ; sed quod tum rectum est, tum modestis Hominibus convenit ; quod quidem evidens est, promptè accipiamus ; quod autem dubium est, per ocium quæramus. ¶.

Errors of the Presse, Correct thus.

PAge. 1. line. 20. read *Plastique*.
page. 5. line. 1. read *Aristoteleans*.
page. 8. line. 2. read *Void*, and line 20. read *δεξιμή*.
page. 10. line. 7. read *Homæmerian*.
p. 13. l. 10. read *rustus acidus*, and l. 25. one and the same, &c.
page. 15. line. 9. read *difficultly*.
page. 17. line. 13. read *Pecquet*.
page. 26. line. 29. read *Pecquet*.
page. 31. line. ult. read, other branches
page. 40. line. 4. read, its own nature, &c.
page. 61. line. 13. read, apposition.
page. 64. line. 4. read, *Venous*.
p. 72. l. 1. r. *Slegelius*, and the same, line. 12.
page. 77. line. penult. read, only thus much.
pag. 83. line. 18. read, draw themselves, &c.
page. 86. line. 22. read *Fracaſtorius*.
page. 89. line. 29. read *lax*.
page. 95. line. 17. read *voided*.
page. 114. line. 7. read *Capsula*.
page. 116. line. 10. read *Nerve*.
page. 157. line. 19. read *Nerve*.
page. 190. line. 8. read, *veins*.
page. 192. line. ult. read, *covered*.
page. 193. line. 17. read *Taylor's Muscle*.



THE CONTENTS.

Exercitation the First.

Of Nutrition.

- A**rt. I. Nutrition and Generation, one and the same Act of the Soul, or Virtue Formative. fol. 1
2. As well in respect of the Matter, as of the Efficient : 2
3. The Necessity of Nutrition, twofold, viz. Augmentation, and Conservation. 3
4. The vital Flame, the Efficient Cause of the Consumption of the substance of the parts. 4
5. The Matter thereby consumed, not the solid substance of the parts, but the Fluid, and chiefly the Blood and Spirits. 5
6. The Manner how they are consumed, is by continual Dispersion. 6
7. And, in what Quantity : 7
8. The Efficient cause of their Renovation, what, 8
9. And what the Material. 9
10. And the Manner how they are renovated. 10
11. A Confectary, of the twofold Expence of the Chyle. ibid.

The Table.

Exercitation the Second.

Of Chylification.

- Art. 1. *The Order of the meat in the stomach.* 11
2. *The posture of the stomach, in Concoction.* ibid.
3. *The Dissolution of the meat, by an Acid Humor found in the stomach:* 12
4. *Which causeth a certain Fermentation of the Chyle therein.* 13
5. *All parts of the Aliment not chylified at once, but successively; and the first chylified, first discharged into the Guts.* 14
6. *The Time required to perfect Chylification, various, according to divers respects.* ibid.
-

Exercitation the Third.

Of the journey of the Chyle.

- Art. 1. *The traduction of the Chyle from the stomach and guts, into the common Receptacle, through the vena Lactea:* 16
2. *Of which there are two Kinds, one arising from the Guts, the other from the Glandules of the Abdomen, into which the former sort exonerate themselves.* 17
3. *But none of either kind tend to the Liver.* 19
4. *That the Milk in the paps, is not made of Blood; but of mere Chyle, brought thither by some peculiar vessells: because* ibid.
5. *There are no convenient conduits, by which blood can be brought into the paps, in sufficient quantity:* 20
6. *Blood is not a fit, nor possible Matter, for the Generation of Milk:* 21
7. *M.R.*

The Table.

7. <i>Milk and Chyle agree in all their manifest Qualities ; and are reciprocally convertible.</i>	24.
8. <i>That Chyle is imported into the womb , in women with child.</i>	25
9. <i>From the Authority of Hippocrates ; and</i>	26
10 <i>Of Dr. Harvey :</i>	28
11. <i>And from the Sympathy betwixt the womb , and the paps.</i>	29
12. <i>A conjectural description of the Chyliferous vessels tending from the paps to the womb.</i>	31

Exercitation the Fourth.

Of Sanguification.

Art. 1. <i>The most part of the Chyle is converted into Blood :</i>	32
2. <i>Not by an Organical, but Similary action.</i>	33
3. <i>Whose primary Efficient, is not the Liver :</i>	34
4. <i>Nor the veins ;</i>	36
5. <i>Nor the Heart ; but the Vital Spirit, residing in the blood.</i>	37
6. <i>Which alone formeth the blood, in a Chicken, out of the Colliquamentum.</i>	40
7. <i>The Manner , how blood is first generated in an Embryo, by that vital spirit.</i>	42
8. <i>In what part of the Conception it is first generated, viz. in the Chorion.</i>	44
9. <i>In the generation of blood , what are the Concurrent Extrinsecal Causes, and what the Accessory Organical.</i>	45
10. <i>The conversion of the Colliquamentum into blood, by the Heat and Motion of the vital Spirit ; illustrated by sundry analogous Experiments , and Observations.</i>	46
11. <i>That</i>	

The Table.

11. That the same Agent, which maketh the first blood in an Embryo, doth make it ever after in an Animal during life.

48

Exercitation the Fifth.

Of the Uses of the Blood.

Art. 1. Blood; not the general Nourishment of the body: because

50

2. The contrary opinion is subject to sundry both inexplicable difficulties, and irreconcilable incongruities:

ibid.

3. There are sundry parts, into whose substance blood is not admitted.

52

4. Fat men generally have the least blood, and lean the most.

53

5. Men perishing by Famine, have their arteries and veins full of blood.

54

6. The blood continueth red and florid, in the habit of the body.

55

7. Hippocrates cured a man of extream Leanness, only by profuse phlebotomy.

ibid.

8. The blood is observed to be less unctuous and glutinous in the Arteries, that carry it to the parts, than in the veins, that return it from them.

56

9. There is a manifest Dissimilitude betwixt the blood, and sundry parts of the body.

ibid.

10. The progress of Nutrition, is from crudity to Fusion and Volatility: not retrograde from Volatility to Fixation; and so the Aliment ought to be more crude or fixed, than the parts to be nourished.

57

11. The blood it self is nourished, and consumes the substance of the solid parts: and therefore cannot be their nourishment.

58

12. The

The Table.

12. *The First Matter, of which the parts are made, is not blood; but a certain liquid juice, very like the white of an Egg.* 60

13. *Nevertheless, blood may be the nourishment of such parts, whose substance is mostly Sanguineous: and what those are.* 61

14. *The Manner, how the Vital Heat is conserved, and the vital spirits continually recruited, ex Sanguine.* 62

15. *The Reason of the Mication; or panting Motion of the blood, in the Arteries.* 64

Exercitation the Sixth.

Of the Motion of the Blood, its Conditions and Causes.

Art. 1. *The Method of the whole Chapter.* 66

2. *That the Motion of the Blood is Circular.* *ibid.*

3. *From the vena Cava, into the right ventricle of the Heart:* 67

4. *From the right ventricle, by the vena arteriosa, into the Lungs.* *ibid.*

5. *From the Lungs, through the Arteria venosa, into the Left ventricle.* *ibid.*

6. *From the Left ventricle, into the Great Artery, and thence into the smaller arteries.* 68

7. *From the smallest Arteries, through the substance of the Flesh, into the smallest veins.* *ibid.*

8. *How the New-made blood is circulated with the old.* 69

9. *That more blood passeth through the Heart, in an hour, than can be supplied from the Chyle, in several dayes.* *ibid.*

10. *The Necessity of this Circulation, inferred from three Considerations, viz.* 70

11. *The*

The Table.

11	{	<i>The Quantity of blood contained in the Heart,</i>	
		<i>in its Diastole.</i>	71
12		<i>The Quantity expelled out of it, in its Sy-</i>	
		<i>stole.</i>	ibid.
13	{	<i>The Number of Pulses, in an hour.</i>	72
11.		<i>That the Circulation is Universal, in all the Ar-</i>	
		<i>teries and veins of the body.</i>	73
12.		<i>But, after a peculiar manner, in an Infant un-</i>	
		<i>born.</i>	75
13.		<i>That this Motion of the blood is Continual:</i>	76
14.		<i>Vehement:</i>	77
15.		<i>Swift:</i>	ibid.
16.		<i>Of equal velocity in the Arteries and Veins.</i>	78
17.		<i>The blood, not the Cause of its own Motion, in</i>	
		<i>respect of any Motive Faculty inherent in it:</i>	80
18.		<i>Nor in respect of its Ebullition;</i>	ibid.
19.		<i>Nor of its Rarefaction;</i>	81
20.		<i>But of its Quantity distending the ventricles of</i>	
		<i>the Heart.</i>	83
21.		<i>The blood not moved by Attraction;</i>	84
22.		<i>Nor by Vection;</i>	ibid.
23.		<i>But by Impulsion of the Heart, endowed with a</i>	
		<i>Pulsifick Faculty; if any such may be admitted.</i>	ibid.
24.		<i>The Fabrique of the Heart, a remote Cause of the</i>	
		<i>Motion of the blood.</i>	87
25.		<i>The Motion of the Heart described, as consisting</i>	
		<i>of two contrary motions, and a Respite betwixt them:</i>	ibid.
26.		<i>And the Figure of it in each.</i>	88

The Table.

Exercitation the Seventh.

Of the Depuration of the Blood.

Art. 1. <i>The Genealogy of the Excrements in the blood :</i>	91
2. <i>Exemplified in the Destillation of Wine :</i>	93
3. <i>The several sorts of those Excrements, and their Definitions.</i>	94
4. <i>The Reason, why each particular Excrement is determinately imported into the part particularly compared for its separation :</i>	97
5. <i>Not that it is so directed by any Intelligence, or Distinguishing Faculty :</i>	99
6. <i>Nor that it is Attracted by the like Excrement contained in that part :</i>	ibid.
7. <i>But, that there is a certain peculiar Conformity of the Magnitude and Figure betwixt the minute particles of this or that Excrement, and the pores of this or that part peculiarly constituted for the reception of it.</i>	100
8. <i>Which is also the Cause of the separation of particular Excrements, in particular parts.</i>	101
9. <i>The Differences of Colatures, used by Nature, in the separation of Humors in the body.</i>	102
10. <i>The Reason and Manner of the separation of the Serum, from the blood, in the Kidneys :</i>	104
11. <i>Of the Phlegmatique Excrement in the stomach and Guts :</i>	105
12. <i>Of the Bilious Excrement's accompanying the Phlegmatique so far.</i>	106
13. <i>Why the blood is not carried immediately out of the trunk of the Vena portæ into that of the Vena Cava; but through the various meanders in the Liver.</i>	109
14. <i>And, why it is transmitted through the Parenchyma of the Liver.</i>	ibid.
15. <i>That the Parenchyma is the principal part of the whole Liver :</i>	110

The Table.

- | | |
|---|-------|
| 16. And a kind of Streyner ; | III. |
| 17. Whose particles are contexed after a peculiar manner ; and pores of divers sorts : in respect whereof the Bile is therein separated from the blood , Mechanically. | ibid. |
| 18. The same inferred from Four Considerables. viz. | II 2 |
| { The equal distribution of the capillary branches of all the vessels of the Liver ; | ibid. |
| { The Pulsation of the vena portæ within the Liver ; | II 3 |
| { The assistance of that pulsation, by the Hepatique Nerve. | II 4 |
| { The Resuscitation of vitality in the blood , in the branches of the vena Portæ, within the Liver ; and a new Fermentation thereof , previous to the separation of the Bile. | ibid. |
| 19. The various Manner of the Excretion of Excrements, after they are separated and collected. | II 6 |
| 20. The particular Manner of the Excretion of the Bile : and | II 7 |
| 21. The Cause thereof. | II 8 |
| 22. Paradox ; that we have a certain Natural Feeling, wholly distinct from the Animal , and independent upon the Brain. | II 9 |
-

Exercitation the Eighth.

Of Respiration.

- | | |
|---|-------|
| Art. 1. The Connexion of this discourse to the precedent. | I 26 |
| 2. The Disparity betwixt Respiration and Pulsation, both as to their Times or periods , and as to their Uses. | ibid. |
| 3. Respiration described. | I 30 |
| 4. The | |

The Table.

4. *The Efficient Cause of Inspiration, is the Dilatation of the Breast, impelling the ambient Aer into the Lungs.* ibid.

5. *And the Cause of Expiration, is only the spontaneous Contraction of the breast.* 132

6. *The Dilatation of the Chest and Lungs, not from any Motive Faculty congenial to the Lungs:* 133

7. *Nor from the impulse of the blood out of the Heart, into the Lungs:* 134

8. *Nor from the motion of the Muscles of the Thorax:* 135

9. *But, from the Diaphragme, moved by a congenite Faculty.* ibid.

10. *Yet the Intercostal and Pectoral Muscles, are allowed to conspire with the Diaphragme, in respiration, violent and arbitrary.* 137

11. *The Final Cause of Respiration, not the Refrigeration of the Heart, or Vital Flame; but, the subtiliation of the blood, which by the admistion of Aer, is made the more convenient fuel of the vital Lamp, and matter of the spirits.* 138

12. *The same exemplified in the accension of flame in wood, by Aer blown out of Bellows: and* 139

13. *inferred from the structure of the Lungs.* 140

14. *The Use of Expiration.* 141

15. *A Problem, of the respiration of the Foetus in the mother's womb.* 142

16. *The motion of the Brain, not dependent upon Respiration, but upon the Pulsarion of the Arteries.* 145

17. *The Secondary Uses of Respiration.* 147

The Table.

Exercitation the Ninth.

Of the Lymphedu&ts.

Art. 1. <i>The Lymphedu&ts a new and excellent invention.</i>	149
2. <i>To whom the honour of their discovery is to be ascribed.</i>	ibid.
3. <i>Their Description.</i>	150
4. <i>Differences.</i>	151
5. <i>Origination.</i>	ibid.
6. <i>Insertion.</i>	ibid.
7. <i>Situation and Progress.</i>	152
8. <i>Liquor, deduced partly from the Arteries, and</i>	153
9. <i>partly from the Nerves.</i>	154
10. <i>The Uses of that Liquor.</i>	155

Exercitation the Tenth.

Of the Distribution of the Nourishment through the Nerves.

Art. 1. <i>That the Nerves are vessells carrying the Nutritive juice to the parts; argued</i>	156
2. <i>From the Atrophy or decay of Nutrition in parts affected with the Pa'sy, and whose Nerves have been wounded.</i>	157
3. <i>From the beneficial use of Cephalique Emplastres, in Consumptions from ulcerated Lungs.</i>	ibid.
4. <i>From the Fatness of men endowed with large, open, and spongy Nerves.</i>	158
5. <i>From the roscid Humor exstilling from wounds of the joynts and sinewes.</i>	ibid.
6. <i>From the Material principle of wemics and Scrophulous</i>	

The Table.

- phulous Tumors.* 159
7. *From the Matter of the seed, and the manner of its preparation in the Testicles.* ibid.
8. *From the Glutinous matter issuing from broken Bones, and cementing them together again.* 162
9. *From the Unequal Nutrition of some parts in the Rickets.* 163
10. *Three grand Difficulties troubling this opinion.* 164
11. *Solution of the First, asserting the possibility of the flux of the Nutritive juice, through the Nerves, notwithstanding no manifest Hollowness be discernable in them.* ibid.
12. *Solution of the Second, yeelding the Reason, why no swelling ariseth in a Nerve, when bound with a ligature, in a living Animal.* 168
13. *Solution of the Third, shewing the Reason why the Nutritive juice is not found in the Nerves of dead bodies dissected.* 169
14. *What is the Principium Elaborationis of the Nutritive juice; viz. the Glandules of the Mesentery, of the Loins, and the Thymus.* ibid.
15. *What the Principium Dispensationis; viz. the Brain, and Spinal Marrow.* 174
16. *What the Vessells importing the same into the Brain and Spinal Marrow; viz. the Nerves, and particularly those of the Sixth Conjugation of the Brain.* 175
17. *What the Motion of the same in the Nerves; viz. not continual, nor vehement: but by intervalls, slow and gentle; to the Brain, in sleep, and from it to the members, after sleep.* 176
18. *What the Causes of that Motion, viz. the motions of the Diaphragme, of the Brain, and of the Nerves themselves.* 178

Exer-

The Table.

Exercitation the Eleventh.

Of Voluntary Motion.

Art. 1. <i>The Inference and Method of this Discourse.</i>	182
2. <i>Requisite to Voluntary Motion:</i>	ibid.
3. <i>That the Animal spirits are the Immediate instruments, by which the soul moveth the Muscles, argued from.</i>	183
4. <i>the Mutation of Figure both in the Muscle and Member moved:</i>	ibid.
5. <i>the Quickness of voluntary Motion:</i>	184
6. <i>the Conquest of the acting Muscle, over its Antagonist:</i>	187
7. <i>the swelling of each Muscle, when it moveth:</i>	188
8. <i>and the privation of motion in a Muscle, whose Nerve is cut off.</i>	ibid.
9. <i>Why a Muscle is composed for the most part of Flesh;</i>	189
10. <i>Of a Nerve;</i>	ibid.
11. <i>Of a Ligament;</i>	190
12. <i>Of a Tendon;</i>	191
13. <i>Of a Membrane investing it;</i>	192
14. <i>And of Arteries and veins.</i>	ibid.
15. <i>That a Muscle is the Immediate Instrument of voluntary Motion.</i>	ibid.
16. <i>Differences of Muscles in respect of their (1) Substance, (2) Quantity, (3) Figure, (4) Situation, (5) Origination, (6) Insertion, (7) Parts, and (8) Actions.</i>	193
17. <i>That the Reason of the Motion of the Muscles, cannot be explained, without having recourse to Mathematical Principles.</i>	196
18. <i>Principles Geometrical, of necessary importance to the understanding thereof.</i>	197
19. <i>Prin-</i>	

The Table.

19. Principles Architectonical, of the same Concern- <i>ment.</i>	201
20. That every Muscle hath a twofold Contraction, viz. Natural and Animal.	203
21. That the Natural Contraction is not the Cause of voluntary Motion; but the Animal.	ibid.
22. That in Motion are two Terms, the one Fixt, the other Moveable, the last of which is more or less, removed from the Former, according to the greater or less resist- ence of Gravity in the member to be moved, and the ve- hementness of the Motion.	204
23. No Motion without Change of Figure.	205
24. which is Threefold, respective to the difference of Angles.	ibid.
25. All Motion is made in one of the two Extreme Figures: and how, demonstrated.	ibid.
26. That a Muscle, in Contraction, is increased in Latitude and Profundity, in proportion to its diminu- tion in Longitude; demonstrated.	207
27. The Necessity of Antagonists Muscles.	208
28. How Circular Muscles are Contracted.	209
29. Why the Sphincters have no Antagonists,	ibid.
30. Conclusion.	210

FINIS.

